FLAMINGOS at the KPNO 2.1-m
An Observer's Guide

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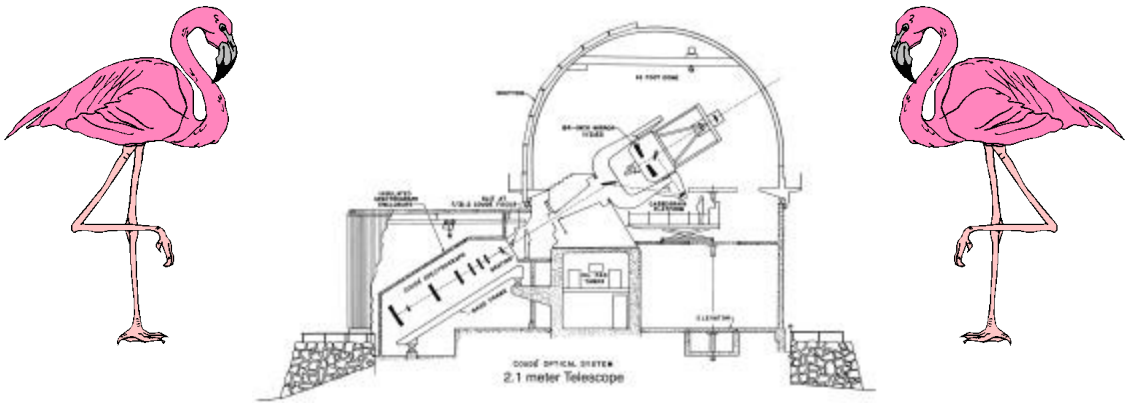

(2.1-m Figure © NOAO/AURA/NSF)

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I. FLAMINGOS + KPNO 2.1-m Overview

FLAMINGOS is the *FLoridA Multi-object Imaging Near-ir Grism Observational Spectrometer*. This manual provides the user with a good portion of the tools needed to successfully take data with FLAMINGOS at the KPNO 2.1-m telescope. The 2.1-m is a completely hands-on facility. The observer runs both the instrument and telescope (there is no telescope operator). You should make certain that you are familiar with the following documents:

- *The 2 meter Observer's Handbook*, available at www-kpno.kpno.noao.edu/2m-manual/.
- *FLAMINGOS at the KPNO 2.1-m: Telescope Console Control Panels & GUIs used for Guiding*, available at http://flamingos.astro.ufl.edu/Manuals/.

You may also be interested in

- *Notes on Mask Design, MOS Plates, WCS's, and Loading MOSplates* (also available at http://flamingos.astro.ufl.edu/Manuals/).

FLAMINGOS is comprised of two cryogenic dewars. The MOS dewar, closest to the telescope backplane, contains a wheel which can position 11 slit plates in the Cassegrain focal plane. The Camera dewar, immediately following the MOS dewar, contains all of the powered optics, filters, stops, grisms, and the detector array. A functional diagram showing the relative layout and connections to the various electronics is shown in Figure 1.

Additionally, an off-axis intensified CCD camera is attached to the instrument mounting adapter; it is meant to be used for guiding, but also may be used for preliminary focus assessment. It is too far off-axis to be used for source acquisition. Please refer to the 2.1-m manuals (listed above) for use of this camera, even if you will not be guiding, as it may be useful for determining initial focus.

Array: Hawaii II 2048×2048 HgCdTe science grade array, divided into four quadrants with 8 amplifiers each (32 amplifiers for the whole array).

Linearity at 1.0 V bias: 0.5% non-linear at 25,000 ADU
2.0% non-linear at 35,000 ADU
>3% non-linear at 40,000 ADU

$S' = 1.00425\ S - 1.01413\times10^{-6}\ S^2 + 4.18096\times10^{-11}\ S^3$ (Anthony Gonzalez, UF)

IRLINCOR coefficients: A = 1.00425 B = -0.03323 C = 0.04489

Plate Scale and Field of View: 0.606 arcsec/pixel
20.7 arcmin FOV

Detector Characteristics

	Imaging	*Spectroscopy*
Bias Voltage (Volts)	1.0	0.75
Full Well (ADU)	~50,000	~38,000
Target Count level (ADU)	25,000 – 35,000	15,000 – 20,000
CDS Read Noise without Differential Amplifier (e)	~40	~40
Gain (e / ADU)	~4.9	~4.1

NOTE: The default bias on boot of the MCE4 array controller is 0.776 V, which is not used in any observing configuration; the initialization script initflam.pl automatically sets the bias to 1.0 V for imaging, but queries the user if they wish to change the bias.

Filters: J, H, K, Ks, JH (0.9 μm – 1.8 μm), and HK (1.25 μm – 2.5 μm) bandpass filters.

Grisms: Two grisms are available, covering the JH (0.9 μm – 1.8 μm) and HK (1.25 μm – 2.5 μm) bandpasses. The HK grism may be used with the HK filter to obtain H- and K-band spectra in first order, or it may be used with the JH filter to obtain H-band in first order, and J-band in second order. For spectra in the K band only, the K or Ks filter may be used to reduce the background.

Long Slits: 2, 3, 6, 9, 12, and 20 pixel wide slits are available; the 3 and 6 pixel slits cover much of the chip but the others slits cover approximately two-thirds of the chip. All of these long slits are located on the MOS wheel. An extra 3-pixel long slit is usually installed in one of the 11 MOS positions.

Spectral Characteristics

Filter / Grism Combination	*Band*	*$R = \lambda / \delta\lambda$ (2 pix slit)*	*Dispersion (Å /pixel)*	*$R = \lambda / \delta\lambda$ (3 pix slit)*
JH + JH-grism	J	1400	4.69	960
	H	1800	4.69	1250
HK + HK-grism	H	970	8.42	650
	K	1300	8.42	865
JH + HK-grism	J (2^{nd} order)	1500	4.4	1000

MOS Plates: **Multiobject spectroscopy is not currently supported at the 2.1-m telescope.** However, several longslit masks can be installed in the MOS wheel, including a single long 3-pixel long slit and custom shorter slits (2, 3, and 4-pixel wide; 2 arcmin long) with a central acquisition hole; 2 or 3 pixel wide slits are customarily used at the 2.1-m telescope.

Position Angles: The 2.1-m guider is removed for the installation of FLAMINGOS, so the position angle of the long slits is fixed at $PA = 0^{o}$. Small rotational offsets of the long slits are possible to accommodate the small residual offset of the instrument from a *PA* of exactly zero.

Mechanisms: The MOS dewar contains the Decker and MOS wheels; the Decker wheel contains an imaging hole, a psuedo dark, and aperture masks to baffle stray light before the MOS wheel. The Camera dewar contains the Filter, Lyot, and Grism wheels; the Lyot wheel contains Lyot stops for the KPNO 2.1-m and 4-m telescopes, and for the MMT; the Grism wheel contains the two grisms, two imaging apertures, ***and the only truly dark cold stop in the system***.

Instrument Control: FLAMINGOS is operated via an ssh connection from either of the MacMinis in the control room (*second-1* or *second-2*) to *flmn-2m-1a* (hereafter referred to as *flamingos1a*), which is the primary FLAMINGOS control computer. FLAMINGOS is set up so that all data taking is run from the command line of *flamingos1a* using a set of perl scripts[1]. *Flamingos1a* is mounted on the right-hand electronics rack with the instrument. A second machine, *flamingos1b* (*flmn-2m-1b*) previously mounted in the rack as a backup data acquisition machine, is nonfunctional and has been removed.

1 Located in /usr/local/flamingos/, in the directories perl_all_tel/, perl_kp2m/, flamingos.headers.lut/, and flamingos_modules/.

Data Acquisition & Storage: While you are taking data, all data will be located on *flamingos1a* in /data/2mguest/<UTDATE>/. If you type df -h, you can see how much of the 68 GB disk space is available; similarly if you type du -h, you can see how much disk space is used in the present directory (the -h option is for human readable format, and it prints values out with KB, MB, and GB suffixes as appropriate). Because ftp on *flamingos1a* is slow, it would be very time-consuming to move the data to another computer at the end of the night, so we utilize a mirror script on the MacMini to continuously copy over the data during the night.

Data Analysis: An IRAF session will be running on *flamingos1a*. Simple analysis tasks such as quick image arithmetic, image stacking, and image statistics can be performed with it while taking data. There are ***no*** pipeline reduction packages installed on *flamingos1a* for imaging or spectroscopy data. If you wish to reduce data simultaneously while taking data, we recommend that you transfer it to one of the MacMinis (usually the one not used for observing) and do so there using the local IRAF package. However, several non-distribution IRAF packages have been installed on *flamingos1a* (*e.g.,* xdimsum) which may be useful .

Data Display: FLAMINGOS images are automatically displayed in ds9, into frame buffers 1 and 2, with odd images in buffer 1 and even images in buffer 2. Other noteworthy points:

- ds9 toggles the frame before loading the newest image, so you sometimes can briefly see the previous image in that buffer. You can choose to tile any of the buffers.
- The image name appears in the file name box in ds9; data values and pixel coordinates are also shown.
- ds9 can read the rudimentary World Coordinate Information (WCS) in the FLAMINGOS header, and it displays the WCS compass arrows.
- ds9 also has some very useful tools such as rulers. You should spend some time familiarizing yourself with ds9 if you are mostly used to ximtool.
- No other display program is available for automatically displaying the images as they are taken.
- IRAF can load images into ds9 with the display command, however, loading images directly into ds9 (with the File/Open buttons) is recommended, as it preserves the ds9 ability to scale the images (using IRAF display suspends this ability).

Data Transport: Observers are responsible for removing their data from *flamingos1a* and transporting it to their home institution. All data may be removed from *flamingos1a* immediately after your observing run. One should run a mirror script on the MacMinis which will automatically rsync the *flamingos1a* data subdirectory to a directory on the MacMini from which it can be copied to a DVD or external USB hard drive. You can also ftp/scp the data to your home institution or to your laptop. Please see *Appendix 1, §G. Data Transfer & DVD Burning*. *The linux machine sapphire previously used for data backup is now a critical systems machine and its use as a workstation is unwise*.

Image Size: Each FLAMINGOS frame is 16 MB in size! During a single night of imaging, it is possible to take 8 – 16 GB of data (500 to 1000 images). Pay attention to disk usage, and bring sufficient storage media.

Unix Tips: Many of the command names are quite long. However, if you type a portion of the command and then hit the TAB key, you will be offered a list of possible completions to the command name. Similarly, the up arrow key will allow you to go up through the history stack of commands entered on the command line. A familiarity with basic unix commands (*e.g. ~, ls, cd, mkdir, rm, rmdir, cp, mv, history, df, du, ps, ctrl-c, ctrl-z, jobs, kill, grep, wc, tar, mt, ssh, scp, ftp* and *the up and down arrow keys*) is useful. ***Some commands which do not require arguments may now be run from a menu on the desktop.***

Halting A Script: Never type **Ctrl-C**. It is much safer to suspend a job with **Ctrl-Z**. Then you can kill the script by typing jobs, and kill -9 %<job number>. If you are moving a wheel, wait for the wheel motion to finish and the script to complete before trying again. If you are taking an image or a sequence of images, wait until the script starts counting the number of seconds elapsed in the exposure before suspending the script. Then run ufstop.pl -clean -stop, and start over. Never type **Ctrl-C** before the exposure time counter has begun.

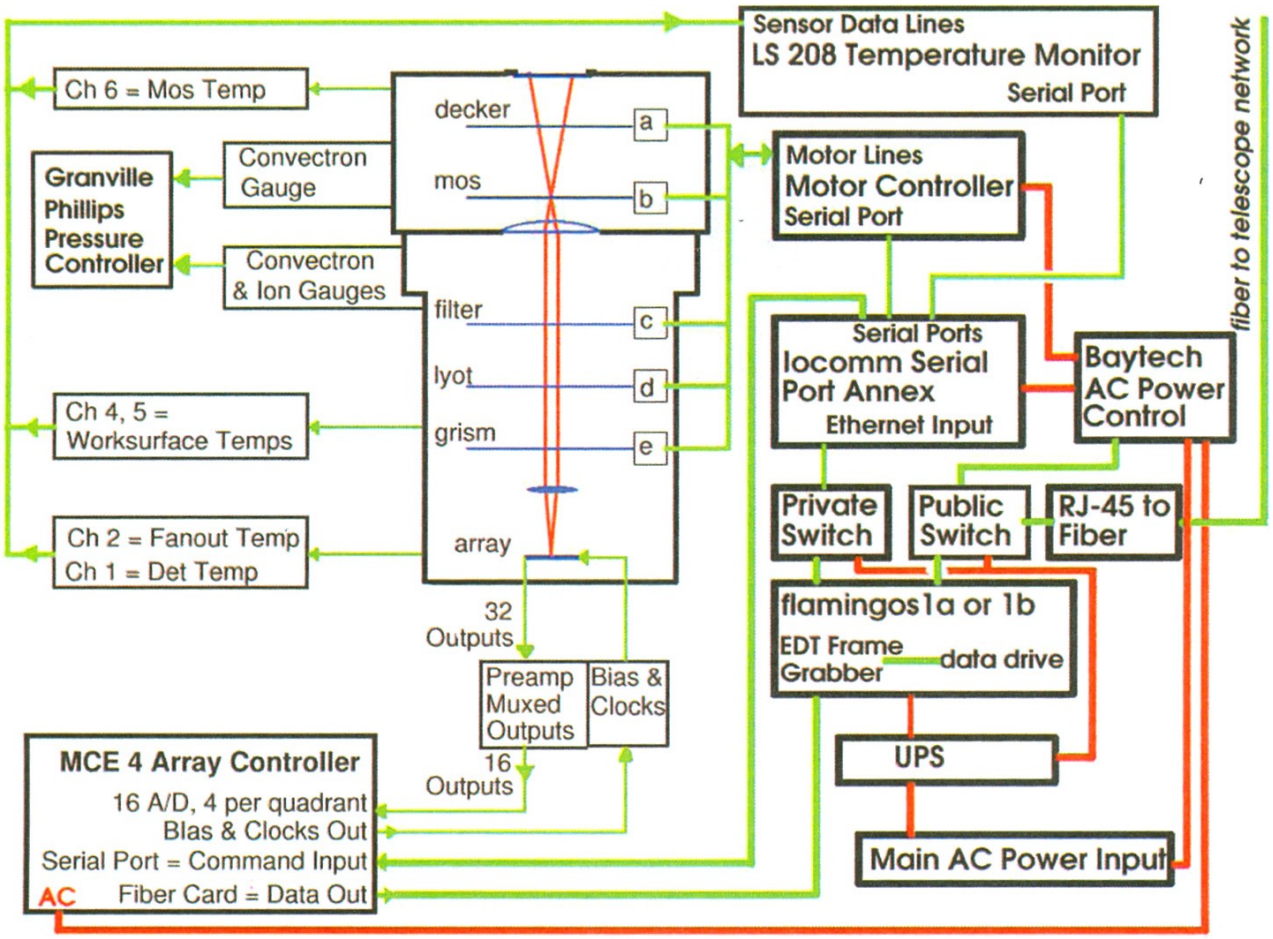


Figure 1: FLAMINGOS Functional Diagram. The relative layout and connections between the various parts of FLAMINGOS are shown schematically. The MOS and Camera dewars are shown in the middle of the figure, including the relative layout of the 5 internal mechanisms above the detector array, and the elements of the two electronics racks are shown on either side of the dewars, much as they are in actuality.

The input beam from the telescope is shown in red; it passes first through the Decker wheel (a baffle wheel) to the MOS wheel at the Cassegrain focus. The beam is collimated (some optical elements are not diagrammed in this figure) before passing through the Filter, Lyot, and Grism wheels, and then through the camera optics to the detector array.

Biases and Clock voltages are input into the array by MCE4, the array controller. All 4 quadrants of the array are read out through all 32 output amplifiers; they are multiplexed down to 16 outputs at the preamp before they are sent into the 16 A/Ds on MCE4. The final output image is then sent via a fiber to the EDT frame grabber on the control computer *flamingos1a* or *1b*, where it is written to the data drive.

The observer makes a remote connection to *flamingos1a/1b* via the RJ-45 to fiber media converter at the instrument's public network switch. The Baytech networked AC power control module is accessible from *flamingos1a/1b* or a Kitt Peak computer, and the observer may toggle the power to MCE4, the Perle (formerly the Iocomm) serial port annex or the Motor controller.

Three software daemons running on *flamingos1a/1b* transfer commands via the private network switch to the Perle (which replaced the Iocomm), which passes the commands to the serial port of the correct device. The three devices are the MCE4 Array Controller, the Motor Controller, and the LS208 Temperature monitor.

Imaging Sensitivity
FWHM = 2 pixels (1.2 arcsec)
Aperture 2.8 arcsec diameter

Band	*e/s for mag=15*	*sky*		*10 σ limiting magnitude*		
		mag-arcsec^{-2}	*e-sec^{-1}-pixel^{-1}*	*60 seconds*	*600 seconds*	*3600 seconds*
J	1050	15.1	335	17.6	18.8	19.8
H	1320	13.1	2815	16.7	17.9	18.9
K	1300	12.7	4028	16.5	17.7	18.7
Ks	1140	12.9	3925	16.3	17.6	18.6
These data are from the KPNO FLAMINGOS web site, http://www.kpno.noao.edu/manuals/flmn.						

The above data were for the original J, H, and Ks filters, which were on loan from NOAO and Gemini. New J, H, and Ks filters were installed during the summer of 2003. The signal levels with the new filters are similar to those in the table.

Decker, Filter, Lyot, and Grism Wheel Positions

DECKER **9000 STEPS**		**FILTER** **1250 STEPS**		**LYOT** **1250 STEPS**		**GRISM** **1250 STEPS**	
dark	0	J	0	Hartmann1	0	open1	0
imaging	2250	H	208	Hartmann2	178	JH	250
slit	4500	K	417	open	357	true-dark	500
mos	6750	HK	625	gemini	536	open2	750
		JH	833	mmt	714	HK	1000
		Ks	1042	4m	893		
				2.1m	1071		

Note that the "true-dark" position in the Grism wheel is the only cold dark stop in the instrument and must be used for obtaining any dark frames.

When using the config.rel.mv.filter.grism.decker.wheels.pl script [Move Wheels], the positions will be split into positive and negative locations centered on the home position to minimize the motion time. Thus, the HK grism will have a location step = -250 in that script.

II.Starting FLAMINGOS

When you arrive at the 2.1-m telescope, you may have to bring up the FLAMINGOS windows and initialize the system (this should have been done during the checkout night). The initial steps of this procedure will hopefully only need to be done once at the beginning of your run; however, you may need to repeat this process during the course of your observing time if you get logged out, or if the system crashes.

The observer interface at the 2.1-m has been significantly upgraded. There are two MacMini computers, *second-1* and *second-2*, each with two 24-inch monitors, which act as observer interfaces to the telescope and instrument computers. As before, FLAMINGOS is run from an ssh session and can be run from either MacMini. Since *second-1* is the primary interface for running the telescope, if there are two observers, one might choose to run FLAMINGOS from *second-2*. ***A solo observer can run both the telescope and FLAMINGOS from second-1, but cannot run the telescope from second-2.*** There are four desktops (called spaces) on the *second-1/2* monitors; moving the mouse to the top right of the right-hand monitor or the bottom left of the left-hand monitor will give a bird's-eye view of all four spaces and can pick one of them with the mouse. This is a convenient feature, which some might find annoying when it occurs without warning.

IMPORTANT: The linux computer *sapphire*, which had been used for backing up data from *flamingos1a* using the autocopy script, is now a critical systems machine for the telescope and is now unavailable for the backup function. Either *second-1* or *second-2* may be used for the offloading of FLAMINGOS data using the mirror script described below and subsequent analysis with IRAF and archiving to DVD or USB hard drive.

The most welcome change is that any of the FLAMINGOS (or other) windows can be moved between the two monitors, eliminating the annoying display environment statements during startup. In addition, one can ssh to the FLAMINGOS computer from *second-1/2* without specifying a login name or password.

Furthermore, some of the commands which do not require arguments may now be run from a menu on the *second1/2* desktop, which can be brought up by double-clicking on the FLAMINGOS icon on the desktop.

For the examples here, we will assume two observers, one running the telescope from *second-1*, the other running FLAMINGOS from *second-2*. The full startup procedure follows:

1. Log on to *second-2*. Choose the 2meter icon; the password _____[taped to the monitor]

2. Once the desktop has come up, open a terminal from the icons at the bottom of the screen

3. In the window, ssh into the FLAMINGOS control computer, hereafter known as *flamingos1a*, as 2mguest:

```
% ssh flmn-2m-1a
```
(It is no longer necessary to specify the login name 2mguest or the password).

4. Start the FLAMINGOS windows in the ssh window which opens. Note one can move them freely between the two monitors

```
2mguest@flmn-2m-1a{1}  ds9 &
2mguest@flmn-2m-1a{2}  xgterm -T IRAF_Flamingos -n IRAF_Flamingos &
```

In the xgterm you just opened start IRAF in the correct directory:

```
2mguest@flmn-2m-1a{3}  cd ~; cd Iraf; cl
```

5. Open an xterm, and initialize FLAMINGOS.

```
2mguest@flmn-2m-1a{4}  xterm -T FLAMINGOS -n FLAMINGOS &
```

Type all following FLAMINGOS commands within this xterm (appropriately titled FLAMINGOS). We recommend that you *move this window to the lower left of the screen*, since the daemon windows will automatically appear in the upper left corner.

6. You are now ready to initialize FLAMINGOS! This is done by running the command

♫ initflam.pl ♫

This script initializes agents and displays the following windows:

Temperature Daemon - This daemon reads temperatures from two different sensors in FLAMINGOS with the following output written to the screen:

```
UFLakeShore208Agent::ancillary
>new reading:(2002:170:05:24:06.920436) 1,75.67 6,82.73 7,83.21
```

You should always keep an eye on the array temperature (~76 K, in the example above where it says 1, 75.67) and the MOS dewar temperature (~83 K, where it says 6, 82.73 in the example above) or MOS worksurface temperature (7, 83.21). The array temperature should never vary by more than ~0.5 K. The MOS dewar temperature must remain below 200 K for successful imaging, although J and H band imaging can be done even with the MOS dewar at room temperature. In normal operation the temperature varies between ~78 K and ~95 K in a sawtooth pattern, depending on the time since the last cryogen fill and the attitude of the instrument; if you are doing MOS observations, please do not let it warm up above 95 K, as the Decker and MOS wheel mechanisms may bind up. Please contact Dick Joyce, Ron Probst or Nick Raines if the MOS dewar deviates from this behavior.

Record Temps window - This window logs both temperatures every 10 minutes. It is sometimes easier to monitor the array and MOS dewar temperatures from here. Please do not close this window or the associated xterm to which messages are printed; you can minimize the xterm messaging window.

Motor Daemon - This daemon controls the motors which move all of the wheels. If the motor daemon does not initialize, answer "n" (for no) to the initflam.pl query about continuing, quit the motor daemon window and run initflam.pl again.

MCE4 Daemon - This daemon runs the MCE4 array controller. The first time this daemon is run, if initflam.pl says it is not ready, look at the MCE4 daemon. If it is printing a string of messages about uninitialized semaphores, quit initflam.pl, quit the MCE4 daemon window, and type ufstop.pl -clean at the 2mguest@flmn-2m-1a prompt. Type **CTRL-C** after ufstop.pl has printed several lines of text and has paused without returning the cursor. Then run initflam.pl once more.

UFSTATUS GUI - This window displays the temperatures, the bias voltage on the array, and the positions of all of the wheels. Please do not close this window or the associated xterm to which messages are printed; you can minimize the xterm. Note that it is *NOT* updated automatically; you must click the update button in the middle of the GUI for the most recent values and positions. *DO NOT* press the update button while any of the wheels are moving.

Array Temperature Quick Look Plot Tool – This GUI will appear, along with an xterm messaging window. Please do not close this window or the associated xterm to which messages are printed; you can minimize the xterm or move it and the plot window to another space on the monitor. After about 30 minutes there will be ~3 points in the *Record Temperatures* log file, and you can hit the Update button to plot the present temperature.

MOS Temperature Quick Look Plot Tool – This GUI will appear, along with an xterm messaging window. Please do not close this window or the associated xterm to which messages are printed; you can minimize the xterm or move it and the plot window to another space on the monitor. After about 30 minutes there will be ~3 points in the *Record Temperatures* log file, and you can hit the Update button to plot the current temperature.

During the first execution of initflam.pl, you will be asked at multiple points whether you wish to continue. In general, if the daemon windows say "listening on port", startup has been successful and you should answer "y" (for yes). If you are re-running initflam.pl after rebooting MCE4 after a detector controller crash (cf. § VII. Troubleshooting), but have left the daemons running (which is OK), the script will complain that the Motor and MCE4 daemons are stalled, however these daemons are probably functioning properly and you can type "y" to continue on.

NOTE: The MacMinis have four desktops (called spaces). If you move the mouse to the top right corner of the right-hand monitor or the bottom left corner of the left-hand monitor, you will get a bird's eye view of all of the four spaces and can pick one, or drag a window from one space to another. This a convenient feature, which some might find annoying, and can be changed. One may also switch to another space by clicking on the "spaces" icon in the dock at the bottom of the monitor screen.

NOTE: We recommend that one close, ***and immediately restart with*** **initflam.pl**, all three daemons (*Temperatures, Motor,* and *MCE4*) once a day. You will also need to close the *Record Temperatures Window*, and to quit out of the two temperature quick-look plotting utilities. We recommend that you do this in the afternoon, possibly right before starting to take a set of pre-dinner dome flats or darks.

III.Nightly Startup Tasks

A. FLAMINGOS Setup

We recommend that you carry out the following procedures prior to each night's observing.

1. *Restart all daemons, temperature logging and temperature plotting windows.* Please see the notes at the end of the previous section. The daemons should all be Quit (not Closed, as this just minimizes them), and initflam.pl immediately re-run, in order to restart the daemons.

2. *Fill Both Dewars.* Observing with FLAMINGOS at the 2.1-m is very much a do-it-yourself operation. In addition to running the telescope and instrument, the observer is responsible for keeping the two instrument dewars full of liquid nitrogen (LN_2), so that they stay cold continuously. You should receive sufficient instruction on this procedure during your startup night at the telescope. If you still have questions, or are uncomfortable with the procedure, please contact the observatory staff for more assistance.

    - Both the Camera dewar (the big one on the bottom) and the MOS dewar (the one on the top) need to be filled with liquid nitrogen at the *start of every night* before you can observe.

    - The MOS dewar also needs to be filled at the *end of every night*.

    CAUTION: The vent of the MOS dewar is about face-level in height. Do not stand close enough to the vent such that liquid nitrogen can splash you in the face!

    Fill the main dewar first and then the MOS dewar using the following procedure, which takes ~15 minutes.

    - Check the pressure and fill gauges on the big storage dewar. The pressure should be ~20 psi and the tank should be more than 1/3 full. If this is not the case, make sure to send a mountain **service** request so that the KPNO elves will come and refill the tank before it gets too low. Also, note that you should give the tank a shake prior to reading the liquid level, as the gauge can get stuck and read too high.

    - Remove the small brass cap at the inlet port on the LN_2 manifold, and connect the fill line from the storage dewar. Use the crescent wrench to *gently* snug the fitting. Do not overtighten.

    - Turn the lower silver valve knob on the manifold counterclockwise to open; this knob controls the flow of LN_2 to the Camera dewar, while the upper valve is for the MOS dewar.

    - Then open the valve on the storage dewar SLIGHTLY, and let the line cool. When you open the valve you should hear a *whooshing* sound from the dewar, and see some initial boiloff.

    - When the *whooshing* stops or changes and/or the fill line looks good and cold, open the valve on the storage dewar all of the way. The dewar is full when liquid is vigorously pouring out of the vent (a *solid* stream, not a trickle) on the South side of the instrument.

    - Once the Camera dewar is full, use the Polar gloves on the work table and close the bottom valve on the manifold. When closing either of these valves, just barely snug them up − they *do not* need to be tight.

    - Now slowly open the upper silver valve on the manifold until it is open all of the way. The MOS dewar may spit quite vigorously at first, but it really is not full. Give it several minutes, after which a solid stream of LN_2 should be flowing out of the vent. ***CAUTION: The vent of the MOS dewar is***

about face-level in height. Do not stand close enough to the vent such that liquid nitrogen can splash you in the face!

- Close the valve on the storage dewar, and remove the line from the inlet port of the LN_2 manifold, then close the silver valve and loosely screw the brass cap back in place. ***CAUTION: Do not simultaneously close both manifold valves and the storage dewar valve. This traps liquid nitrogen within the fill line, with potentially nasty consequences.***

3. *Remove the MOS dewar window cover.*

   The MOS dewar window is continuously flushed with dry nitrogen gas from an annular copper ring mounted on the top of the dewar connected by a hose to one of the dry nitrogen regulators on the telescope backplate. During the daytime the MOS dewar window is covered by a plastic cover (recycled Frisbee) which also fits over the copper ring, ensuring that the window environment remains clean and dry. **This cover must be removed prior to observing and and replaced at the end of the night or if one closes due to weather**.

   Begin standing on the north side of FLAMINGOS, facing south:

   - On top of the MOS dewar you should see two large tubular sliding aluminum panels, with their junction directly in line with the guide camera. Slide the panels open and away from each other.

   - Using a flashlight, look inside. The Frisbee has a cutout for the guider pickoff mirror, but is otherwise not secured in place.

   - ***Carefully*** reach in and lift the Frisbee off of the window. You may have to rotate it slightly to clear the guide pickoff mirror. *Do not* scratch the window or guide pickoff mirror during this procedure.

   - Slide the panels back together. Make certain there is a ~3 inch gap remaining, so that light from the pickoff mirror still makes it to the guide camera, and that the nitrogen hose is not crimped.

4. *Create a data directory for the night on flamingos1a* **.**

   From any *flamingos1a* window:

   ```
   2mguest@flmn-2m-1a{5}  cd  /data/2mguest/
   ```

   - Create a directory on *flamingos1a* with the UT date in the format YYYYMMDD (or whatever designation you prefer), *e.g.,:*

   ```
   2mguest@flmn-2m-1a{6} mkdir 2003sep15ut
   ```

   - Verify that *flamingos1a* has sufficient available disk space. Typing `df -h` on *flamingos1a* shows the following output:

Filesystem	Size	Used	Avail	Use%	Mounted on
/dev/dsk/c1t0d0s0	9.3G	1.3G	7.9G	15%	/
/dev/dsk/c1t0d0s1	9.3G	2.7G	6.5G	29%	/usr
/dev/dsk/c1t0d0p0:boot	11M	1.7M	9.0M	16%	/boot
swap	951M	12K	951M	1%	/var/run
swap	961M	9.2M	951M	1%	/tmp
/dev/dsk/c1t1d0s0	68G	29G	38G	44%	/data
/dev/dsk/c1t0d0s2	16G	2.5G	13G	17%	/home

In this example the data disk on *flamingos1a*, /data, is 44% full, and has 38 GB of available space. For imaging you should ensure that there is at least 10 GB of space available; for spectroscopy you should have ~5 GB of space. However, note that the image acquisition scripts will complain on each and every image if the *flamingos1a* disk space is ≥ 93% full, and will refuse to take any more data if the disk is ≥ 97% full.

5. Open the shortcuts menu. Many of the common FLAMINGOS commands which do not require arguments may now be run from a shortcuts menu on the *second-1* or *second-2* desktop. Double-click on the FLAMINGOS icon to bring up the menu (Figure 2). In the following, the appropriate button will be noted in square brackets along with the command line input.

Figure 2: Command menu on the *second-1/2* desktop.

BUTTON	FLAMINGOS COMMAND
Configure Exposure	config.exposure.pl
Set Exposure Time	set.exposuretime.pl
Initialize Wheels	engineering.config.filter.grism.decker.wheels.pl
Move Wheels	config.rel.mv.filter.grism.decker.wheels.pl
Move MOS Wheel	config.rel.mv.mos.wheel.pl
Set Dither Pattern	config.dither.kpno.pl
Execute Dither	dither.source.kpno.pl
Take Image	singleimage.pl
Abort Dither Script	[aborts an ongoing dither script]

6. Set up header information, data location, file names. Several parameters need to be set before taking an exposure. The script config.exposure.pl [Configure Exposure] will print out a list of exposure parameters, and query if you wish to change any of them. If you do, you can step through each of the modifiable parameters; enter the new value or hit return to keep the old value. Here is a complete list of parameters that are printed out:

OBS_TYPE	Type of observation being taken; commonly used keywords are object, standard, flat, dark.
OBJECT	Name of object being observed. **NOT** provided by TCS.
FILEBASE	Image filename's prefix; the naming convention is filebase.####.fits where the numbers (####) are automatically incremented by the data taking script from 0001 to 9999.
ORIG_DIR	Absolute pathname of the directory to which you wish to write data. Make sure you include the trailing / on the pathname.
DATE_OBS	UT date at the end of the night (YYYY-MM-DD). Provided by TCS.
EXP_TIME	Exposure time for integration in *seconds*. Must be an **integer** ≥ 2 and at least twice the value of the parameter NREADS.

NREADS	Integer number of non-destructive reads per endpoint per image.
	• For imaging use NREADS = 1, which corresponds to Correlated Double Sampling (CDS).
	• For spectroscopy you can use multiple read sampling:
	  • The minimum value is NREADS = 3.
	  • The maximum recommended value is NREADS = 8.
	  • The minimum allowable EXP_TIME is 2×NREADS.
	  • Note that this script does not always rigorously enforce this condition, so please double check that EXP_TIME and NREADS are mutually consistent.
	• For NREADS ≥ 3 the output image will have signals NREADS times higher than for a CDS frame; *i.e.,* the output image is a coadd, not a coaverage frame.
	• A schematic of the readout scheme appears in Figure 7, *Appendix 2*.

BIAS	The value of the *last requested bias* is recorded here. The imaging bias is 1.0 V; for spectroscopy one uses a bias of 0.75 V, which yields a substantially lower dark current, although at the cost of some well depth. *To determine the actual bias value hit the* Update All *button on the UFSTATUS GUI.*
WEATHER	A numerical descriptor of common environmental conditions (1=photometric, 2=thin cirrus, 3=broken clouds, 4=overcast, 5=snowing, 6=fog).
WIND	A numerical range descriptor of the wind speed (1=calm, 2=low, 3=moderate, 4=high, 5=closed).

After prompting you for all of these parameters, config.exposure.pl will ask if you want to change the bias. If you answer "y" it will automatically run the script set.bias.pl. In imaging mode, the bias should always be set to 1.0 V.

7. Take an image. Execute the command singleimage.pl [Take Image]. This will take one image with the exposure time specified by config.exposure.pl and display it on the ds9. The first image after starting up may look bad, so take a second one if this is the case.

8. Verify Telescope. After taking the first image, use the File/Display Fits Header pulldown menu on the ds9 display to verify that the TELESCOP keyword is correctly set to 2m. If it is not, the scale on the display will be incorrect and the MOS setup routines will not work. It will be necessary to run the script config.location.pl -telescope kp2m to reset the telescope to the KPNO 2.1m. Because this loads a default header, one must run config.exposure.pl again to reset the parameters.

9. Execute Mirror Script on second-1/2. Run the mirror script on one of the MacMinis (usually the one not used for observing) to automatically move the data from the *flamingos1a* data directory to a directory on the

MacMini for analysis or archiving on storage media such as a USB drive. From a terminal on *second-1* or *2*, run

```
% ~/bin/mirror  flamingos1a  /data/2mguest/<dir>
```

where <dir> is the data subdirectory in /data/2mguest on *flamingos1a*. It is probably safest to use the full path name. The command will create the subdirectory <dir> on the MacMini, in whichever directory you ran the mirror command and will use rsync to update the files every 30 seconds. Keep the terminal window in a safe place so it is not inadvertently closed; it will keep reporting when new files have been transferred. You can stop the process with crtl-C.

B. Startup on the Sky

Several of these steps refer to commands that are described in more detail in section ***§ IV. Imaging with FLAMINGOS*** (*e.g.,* for details on how to configure the wheels and how to set the exposure time).

As noted at the beginning of the manual, there is no KPNO telescope operator at the 2.1-m telescope, except for the first few hours of the initial night of an observing run to instruct the observer on the operation of the telescope and to ensure that everything is working properly. After this initial checkout, the observer(s) operate both the telescope and FLAMINGOS. In the case of two or more observers, one will generally assume the role of operating the telescope. The observers should become familiar with the following documents:

- *The 2 meter Observer's Handbook*, available at www-kpno.kpno.noao.edu/2m-manual/.
- *FLAMINGOS at the KPNO 2.1-m: Telescope Console Control Panels & GUIs used for Guiding*, available at http://flamingos.astro.ufl.edu/Manuals/.

1. *Open up the telescope for the night*
   - Follow the checklist for bringing up the TCS, opening the dome and initializing the telescope.
   - Turn on the off-axis guide camera, and the acquisition and guide video displays.
   - After setting up on a star, focus the telescope on the guide camera, looking at the acquisition video display (this shows the direct readout). At best focus, stellar images usually have a tight core and a noticeable tail to the South because one is so far off-axis.
   - **NOTE:** For imaging programs, one will often not use the guide camera and rely solely on the large FLAMINGOS field for target acquisition.

2. *Verify FLAMINGOS is set up for imaging*. The Decker and MOS wheels should both be at imaging, the Lyot wheel should be at the 2-m stop, and the Grism wheel should be at position open1. Use config.rel.mv.mos.wheel.pl [Move MOS Wheel] and config.rel.mv.filter.grism.decker.wheel.pl [Move Wheels] to move the wheels. For the first motion of the night, use the Initialize Wheels button; this will use the home switch to zero the wheels. The H filter is quite useful for these startup tasks.

3. *Center a bright star to within 10 pixels of (x,y)=(1024,1024) on FLAMINGOS.*
   - Within ds9 you can draw rulers from the approximate center of the star to the center of the array.
     - Double clicking on the ruler line will pop up a GUI with the length of the ruler line and its decomposition in detector (x,y) coordinates. The starting and ending (x,y) coordinates of the ruler are also listed and are modifiable.
     - Enter the values for the center of the star for one endpoint of the ruler, then enter in (1024, 1024) for the center of the array for the other ruler endpoint. Afterwards click the Apply button at the bottom.
     - Next, hold and select the Distance pulldown button and choose the Arcseconds distance scale. The numbers in the window will change accordingly.
   - Use relative.offset.kpno.pl δRA δDec to offset the telescope.

- Note: δRA and δDec must be in arcseconds (see the previous step).
- Look at the compass arrows in ds9 to determine which of (x, y) corresponds to (RA, Dec); you may have to darken the display to create enough contrast to see the arrows clearly. With FLAMINGOS mounted onto the 2.1-m in the usual way, moving an object from its present location by (+dx, +dy) in detector space corresponds to (-δRA, +δDec).

- Take another image, and iterate with rulers and relative.offset.kpno.pl until the star is centered.

4. *Zero the telescope pointing.*

5. *Verify optical alignment.* During the first pointing check of the observing run, it is advisable to take an image of a very bright star way out of focus, to verify that the pupil stop has not been moved, and that the mirror covers and dome are open and positioned properly. You should see a bright donut, with shadows for the secondary and the spider vanes. If the donut is not circular (*e.g.*, has a sliver missing at the outer edge) there may be something vignetting or the Lyot wheel may need adjustment.

6. *Optimize focus on sky near first target field.* The guide camera should have been set up to be confocal with FLAMINGOS during the first night of the observing block. You should be able to get close to a good starting focus for FLAMINGOS by checking the focus on the guide camera's acquisition video display. Then you should do a short focus run about that point (with steps of 50 units) on FLAMINGOS.

   - Use an exposure time ≥ 10 seconds to average over seeing fluctuations.

   We suggest using the tasks in the new flmntools IRAF package written by Anthony Gonzalez (UF) for assessing image quality. However you can also use the IRAF task imexam, in the standard manner. We detail the use of both here. One may use the IRAF_FLAMINGOS window which is linked to the ds9.

   - The flmntools tasks fwcheck and fwscan take differences of images, and then run SExtractor on the central 1250×1250 pixel region to determine the average FWHM; sources brighter than 10,000 ADU in the difference image are ignored and objects with FWHM < 1.3 pixels are rejected as cosmic ray hits. To use these, first enter the flmntools package to get the following prompt:

```
cl> flmn
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 Welcome to FLMNTOOLS - The FLAMINGOS Observing Tools
  ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 Tasks included are:

 fwcheck   - Quickly check the fwhm and display the difference image
 fwscan    - Compute the fwhm for each frame in a set of observations

     fwcheck  fwscan
fl>
```

   This package is used at more than one telescope, so on the off-chance that the parameters have been unlearned, verify the telescope field is set to KPNO2.1m:

```
fl> epar fwscan

PACKAGE = flmntools
      TASK = fwscan
```

```
root    =          ugc3371.j    Root infile name?
First   =                 21    First image in set?
Last    =                 25    Last image in set?
(telesco=       KPNO2.1m)      Telescope(MMT, Mayall, KPNO2.1m)?
(mode   =                 q)
```

- fwscan takes a range of images as inputs, in the form

  fwscan <image root name> <First image number> <Last image number>

  It computes running difference images from which it computes the FWHM. You can use this to monitor the seeing during a sequence of observations. To use this for focus runs, *e.g.,*

  - 2mguest@flmn-2m-1a{17} singleimage.pl
  - 2mguest@flmn-2m-1a{18} relative.offset.kpno.pl 10 0
  - Increment the focus (typically 50 – 100 units).

  Repeat these three steps as necessary, offsetting the telescope back and forth between each image. Once you've taken 2 or more images epar fwscan to make certain it is set up for the 2.1-m, then run fwscan. Here's some sample output:

  fl> fwscan ros25h 1 9

#Main Frame	Bkgd Frame	Average	Median	1st Quartile	#stars
1	2	1.49"	1.48"	1.34"	235
2	1	1.37"	1.37"	1.25"	213
3	2	1.40"	1.39"	1.30"	189
4	3	1.67"	1.67"	1.51"	205
5	4	1.49"	1.48"	1.31"	201
6	5	1.55"	1.56"	1.44"	146
7	6	1.43"	1.42"	1.26"	152
8	7	1.39"	1.39"	1.31"	97
9	8	1.56"	1.55"	1.43"	84

- fwcheck differences only two frames, computes the FWHM, displays the difference frame in buffer 4 of ds9, and finishes with an imexam cursor on the image. To call it:

  fwcheck <image root name> <background image number> <source image number>

- Some notes on using imexam, in the standard manner:

  - After an image has displayed in ds9 type imexam *with no arguments* at the cl> prompt[2]. You can keep imexam open as you continue to take focus images.
  - Use the r, a, and e keys to obtain information on the image quality.
  - We usually use the Moffat fit number (the second fit number from the right after hitting the a or r keys) for characterizing the image quality.
  - FWHM of 2 – 2.5 pixels over the entire chip are respectable (1.2 – 1.5 arcsec).
  - Optimize focus on stars out about 350-500 pixels in radius from the center of the chip.
  - Stay away from the left edge, however, as it is slightly more out of focus than the rest of the array.

2 Note that if you type in the image name, IRAF will have to redisplay the image and possibly will not choose a useful image scaling; it will also disable the scaling buttons in ds9. It is generally better to use the ds9 File/Open menu in order to display an image rather than type display in IRAF.

7. *Variation of focus with temperature and airmass.* The telescope changes focus due to temperature variations; the focus value will increase with decreasing temperature. Similarly, the focus value will decrease as the airmass increases:

   - *Temperature Variation:* $\Delta T(+1\ C) = -75$ focus units
   - *Airmass Variation:* $\Delta X = -130$ focus units

   It's advisable to watch the temperature every 30 – 60 minutes, and if necessary adjust the focus.

8. *Check the display orientation.* A raw FLAMINGOS image on the nominal ds9 display (no image flip or rotation) has *earth parity* (E is cw from N), with the instrument position angle (0º) at the bottom of the display (Figure 3).

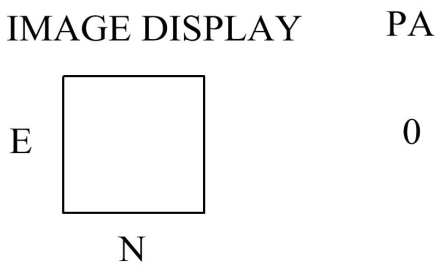


Figure 3: Orientation of a raw FLAMINGOS image on the ds9 display at the 2.1-m (PA = 0).

9. *Other Useful Bits:*

   The **snowflake icon** on the *second-1* and *second-2* desktops will display the truss temperature.

   The **windsock icon** on the *second-1* and *second-2* desktops will display the current weather at the 4-m telescope.

You are now ready to start observing!

IV.Imaging with FLAMINGOS

A. Overview

FLAMINGOS may be used for imaging through J-, H-, K-, and Ks-band filters. Sky emission in these bands is variable and may be bright[3]. Exposure times are kept reasonably short as a result and guiding is not required. The general observing procedure is to point the telescope in a dither pattern about the source, taking one or more images at each location. FLAMINGOS has a dither script with several different dither patterns available. They all are oriented in a square grid in (RA, Dec); the ordering through the pattern is executed in the same psuedo-random order every time (it is not a raster).

For deep imaging, exposure times up to 120 seconds in the J-band, and up to 30 – 90 seconds in the H- and K-bands are common. The shortest possible exposure time used with FLAMINGOS for scripted observing is 2 seconds. There is also a special script which will take a single exposure at the fastest possible exposure time of 1500 milliseconds immediately upon execution.

NOTE: FLAMINGOS has two integration timers, a milliseconds timer for exposure times ≤ 60 seconds, and a seconds timer for exposure times ≥ 60 seconds. The seconds timer was determined to have a total timing error range of ~ 1 second[4]; the array controller hardware code was updated in August 2003, and this problem should have been eliminated, however we have not yet evaluated the engineering data. Some observers choose to use 60 seconds as the maximum exposure time they will use for their observations, in order to use only the milliseconds timer.

The default bias for imaging is 1.0 V; the present value may be obtained by hitting the Update All Items button on the UFSTATUS GUI. The MCE4 array controller supplies this bias automatically on boot, after initflam.pl has been executed.

The general outline for imaging observations is:

1. For every new target, verify telescope pointing on a SAO or Fixed Bright star close to the target position by imaging the star on FLAMINGOS, offseting the telescope until it is well centered on the science array, then Z the telescope *(cf. § III . B. Nightly Startup Tasks: Startup on the sky*).
2. Acquire target close to the center of the FLAMINGOS field of view.
3. Check focus.
4. Execute imaging dither pattern.
5. Repeat steps 1 – 5 on standard, if desired; there are a number of IR standard star caches at the 2.1-m, including the HST/NICMOS, UKIRT, and ARNICA standards. Some observers choose to use 2MASS sources within the target fields.
6. Take any required dome flats. These may be done in the afternoon.
7. Take darks (10 - 20 each) at every exposure time that was used if sky flats are desired. These may be done in the afternoon.

The following list of commands is useful for imaging and for spectroscopy (described in the next section). A more detailed explanation of several of these scripts directly follows the list.

NOTE: After the home switch on the Grism wheel failed in 2009, new scripts for relative motion of the wheels were generated. The relative MOS wheel script must be used, as there is no home switch. We recommend using [Initialize Wheels] for the *first* motion of the Decker, Filter, and Grism wheels to ensure the home is correct and [Move Wheels] thereafter, since the motions are shorter.

3 In the J and H-bands the emission is mostly generated by OH in the atmosphere at elevations of 90 km.
4 Mark Dickinson discovered this problem. See his analysis at: www-int.stsci.edu/~med/flamingos/fewompt_plus.html.

On the FLAMINGOS command line:

config.dither.kpno.pl	Set up a sequence of images dithered about a common pointing center.
config.exposure.pl	Set filename, storage directory, exposure time, and number of reads, as well as several descriptive fields.
config.filter.grism.decker.wheels.pl	Set up and move Filter or Decker wheel.
config.rel.mv.filter.grism.decker.wheels.pl	Execute *relative* motion of Filter, Grism, or Decker wheel
config.rel.mv.mos.wheel.pl	Set the MOS wheel position (imaging = 10).
dither.source.kpno.pl	Execute data acquisition in the selected pattern.
fast.singleimage.pl	Take a single 1500 ms exposure time image.
more.singleimages.pl <n>	Take n consecutive images with the present system configuration.
offset.kpno.pl <dra> <ddec>	Offset telescope with respect to base pointing center.
relative.offset.kpno.pl <dra> <ddec>	Offset telescope with respect to present pointing center.
set.bias.pl	Set the detector bias voltage; shortcuts for imaging (i) and spectroscopy (s) may be typed to select common values.
set.exposuretime.pl	Set integration time (seconds) and number of reads only.
set.filename.pl	Set the filename and data directory only.
singleimage.pl	Take a single image with the present system configuration.

B. Wheel Setup for Imaging

FLAMINGOS has five wheels in its optical path, each containing various filters, pupil masks, and spectroscopic slits. Hit the Update All Items button on the UFSTATUS GUI to determine the present location of the wheels. In imaging mode the following configuration should be in place:

- Decker Wheel (motor a) should be set to imaging.
- MOS Wheel (motor b) should be set to imaging.
- Filter Wheel (motor c) should be set to one of the following bandpass filters: J, H, K, Ks, JH, HK.
- Lyot Wheel[5] (motor d) should be set to 2.1-m.
- Grism Wheel (motor e) should be set to open1.

If all you plan to do is imaging, then it is not necessary to adjust the Decker or MOS wheels once they are set. If the MOS wheel is not positioned correctly, use config.rel.mv.mos.wheel.pl [Move MOS Wheel]to select the imaging aperture. Use engineering.config.filter.grism.decker.wheels.pl [Initialize Wheels](first motion) and config.rel.mv.filter.grism.decker.wheels.pl [Move Wheels] to set the indicated wheels. The Lyot wheel should not need to be adjusted. Each of these scripts will first query and then print the current motor positions.

- The MOS script will query if you wish to change the setup; answering "y" will cause a list of 17 named positions to appear. Type 10 to select the imaging position. Next, the script prints out a detailed information window, the last bit of which shows the desired move. Answering "y" at this point will issue the wheel motion command.
- The filter/grism/decker script will ask for the motor name (c, e, or a, respectively) before providing a list of valid positions. Note that position 0 for each wheel is the home position. As with the MOS script, the script will print out a detailed information window, the last bit of which shows the desired move. Answering "y" at this point will issue the wheel motion command.

For both scripts the wheel motion status will be queried approximately every 5 seconds, and the result will be

5 If the power to the motor controller has been cycled, the GUI will claim that the Lyot wheel is at Hartmann1. The Lyot wheel should have been set during the first engineering night of the FLAMINGOS run at the 2.1-m, and should not need to be adjusted.

printed to the screen. It is unnecessary to hit the Update All Items button on the UFSTATUS GUI during execution of either of these scripts. It is, however, a good idea to update the GUI after the script has successfully completed.

NOTE:

- It is not possible to move more than one wheel at a time.
- **The only useful dark position is on the Grism wheel**; there is a dark position on the Decker wheel, but it does not provide a truly dark condition, since it is not directly in front of the detector.
- Once the script has started moving a wheel, do not attempt to abort it. Just wait for it to finish moving, and run the script once again.

C. Configuring an Exposure

Several parameters need to be set before taking an exposure. The script config.exposure.pl [Configure Exposure] described in § III.A.5, will print out a list of exposure parameters, and query if you wish to change any of them. If you do, you can step through each of the modifiable parameters; enter the new value or return to keep the old value.

If you wish to change just the exposure time or the filename, and don't want to run through the entire list of parameters, then use set.exposuretime.pl [Set Exposure Time] or set.filename.pl.

D. Taking Images at a Single Pointing

The most useful script for quickly looking at an image with the current telescope pointing and instrument configuration is singleimage.pl [Take Image]. This takes an image immediately upon hitting return and displays in ds9.

E. Taking Dithered Images

FLAMINGOS also has the ability to take a sequence of images using a set of pre-determined dither patterns. In order to configure the dither pattern, run config.dither.kpno.pl [Set Dither Pattern]. This allows you to change the following parameters:

DPATTERN	The desired dither pattern. Your choices are 2×2, 3×3, 4×4, 5×5, 5box, 5plus, and 45rot_5×5 pattern rotated by 45 degrees. The offsets always are in the form of (δRA, δDec). The 5box pattern is the 2×2 pattern with the central pointing; 5plus is the 5box pattern rotated by 45 degrees.
D_SCALE	Additional scale factor for the offsets. The default of D_SCALE = 1 will add a border to your images of 30", for a net increase of 60" to the total field of view of the final stacked image, *for any of choice of DPATTERN.*
D_RPTPOS	Number of times to repeat each dither position.
D_RPTPAT	Number of times to repeat the entire dither pattern.
STARTPOS	Starting position in the dither pattern, where 0 is the first position of the pattern. This is very useful if the system crashes or hangs mid-sequence, however do not forget to reset it back to 0.
USENUDGE	Nudge pointing center on pattern repeats; 0 = do not nudge, 1 = perform nudge.
NUDGESIZE	Radial size in arcseconds of nudge, randomly chosen in one of the cardinal (ra, dec) directions.
THROW	Radial length in arcseconds to other nod beam (not functional in imaging mode).
THROW_PA	PA of other beam for nodding (not functional in imaging mode).

After you have configured your dither sequence, run dither.source.kpno.pl [Execute Dither] to execute the dither

pattern and take images. Immediately after hitting return this script print out information about the requested dither pattern, and it will ask you to type either HOME or CLEAR before beginning the dither pattern.

If you have any offsets showing on the TCS, typing HOME will cause the script to dither about the pointing center where the offsets are (0,0), while typing CLEAR will absorb any offsets present into the current pointing coordinates, and dither about that new position (i.e., it will perform a Z of the telescope coordinates). **One will almost always want to enter CLEAR, since the telescope will generally be at the desired initial position**. See the next section on offsetting the telescope from the FLAMINGOS command line.

You can monitor seeing variations and any focus drift if you continuously use fwscan while the dither pattern executes; just start using it after the first two images have read out.

F. Offsetting the Telescope from Flamingos1a

At certain times (such as pointing checks or adjusting the position of your sources on the detector) you may wish to offset the telescope directly from *flamingos1a* rather than from the telescope console. To do so use the following commands:

offset.kpno.pl <RA> <Dec> - Offsets the telescope in an *absolute* sense with respect to the pointing center, where the telescope offsets are (0,0). Offsets are in arcseconds and positive values move the telescope East and North from the pointing center. For example, offset.kpno.pl 5 10 will set the telescope pointing 5" East, and 10" North. Repeating this command with the same offsets will not move the telescope.

relative.offset.kpno.pl <RA> <Dec> - Offsets the telescope *relative* to wherever the telescope is presently pointed. Offsets are in arcseconds and positive values move the telescope East and North from its *current* position. In this case, relative.offset.kpno.pl 5 10 will move the telescope 5" East and 10" North. If the offsets initially were (0, 0) then after this move they will be (5, 10); repeating this command will move the telescope and the new net offsets will be (10, 20).

Typing offset.kpno.pl 0 0 will send the telescope back to the starting pointing center.

Typing clear.offsets.kpno.pl will allow you to define the present net pointing (base plus offsets) as the pointing center. It will cause the telescope to reset the offsets on the TCS to (0,0) but the telescope will not move (the same as performing a Z of the telescope coordinates).

NOTE: *The absolute and relative offset commands are not meant to be used when guiding (cf. Section V* on spectroscopy).

G. Taking Darks

Darks need to be taken at every exposure time that was used for science observations (except for bright standards, where the sky level is low) to generate sky flats. Generally 10 – 20 images are taken per exposure time for averaging; one may take these during the daytime. To take a single set of images at the same exposure time, use the script

more.singleimages.pl <number of image desired>

If the required darks have a long exposure time, consider starting them going as you walk out the door to go to bed. *Be very certain to check on the quality of the data once you get up*—the array controller may hang midway through the data set, or have a glitch which affects some of the images.

If you need to take many darks at several different exposure times, consider writing a cshell (csh) script which consecutively calls config.exposure.pl and more.singleimages.pl multiple times, each time passing the proper keystrokes into each script. An example, based on a script written by Anthony Gonzalez (UF), appears in

~2mguest/bin/Example.many.scripted.darks.csh

Note that the blank lines are very important!

Also, be very certain to check later that the script completed successfully; *cf.* ***§*** *VIII. Troubleshooting* for possible failure modes, such as bad reads, scrambled images, zero frames, and MCE4 hangs.

H. Dome Flats

Although most observers use sky flats generated from the target observations, one may take dome flats as a backup. These can be taken at the end of the night or during the afternoon, although one may have to wait until 1600 hr when the spotlights for the Visitor Gallery turn off. During the daytime, one should open the mirror covers only with the telescope at zenith, then use Go to White Spot from the shortcut menu. Naturally, do not open the mirror covers if the weather is questionable or the dome is wet.

Instead of taking darks for bias and dark current subtraction, we recommend taking a series (10 – 20) of flats with the lamp at the proper intensity to yield signal levels in the 10000 – 15000 ADU range and a second series with the lamp turned off. These two sets are then averaged and subtracted to eliminate the bias and dark current, as well as any ambient background light and thermal emission.

I. Custom Scripts

Various user scripts are located in the directory ~/bin and have the general format <scriptname>.csh. To create a custom script, cd ~/bin and copy an existing script to a new name:

cp <scriptname>.csh <newscriptname>.csh

After editing the new script, you may execute it from the command window with

~/bin/<newscriptname>.csh

V. Taking Spectra with FLAMINGOS

A. Overview

FLAMINGOS may be used for obtaining long slit spectra at the 2.1-m; please see *§ I. FLAMINGOS + KPNO 2.1-m Overview* for resolving powers within selected passbands. **Multiobject spectroscopy is currently supported only at the 4-m telescope.** As with imaging, the sky emission is variable and bright, and there is additional background in the HK mode from the camera dewar window. It is necessary to subtract this contribution from the target spectrum. This is accomplished by dithering the target up and down the slit. Two possible techniques are walking up the slit at 5 to 7 different locations, and nodding the telescope back and forth between two offset positions, A and B, in an ABBA pattern, symmetrically placed about the target's initial alignment position. Dithering in an ABBA pattern can be done by hand, or automatically with a script. Walking up or down the slit must be done by hand.

Telescope guiding is required, as the integration times are generally long, and the time to align a long slit or MOS plate is also significant. The guide camera is an intensified CCD attached to an extension to the instrument mounting adapter on the North side of FLAMINGOS. It is fed by a folding mirror mounted at the periphery of the MOS dewar vacuum window. Consequently, the guider field of view is about 160" East and 1500" South of the FLAMINGOS pointing center[6]. The guider plate scale is ~0.53" pixel^{-1}, and the field of view is about 5.6' in RA × 4.2' in Dec.

The default bias for spectroscopy is 0.75 V, where the array has lower dark current than at the imaging bias of 1.0 V. The current bias value may be obtained by hitting the Update All Items button on the UFSTATUS GUI. **NOTE:** the MCE4 array controller automatically sets the bias to 0.776 V on boot, which is not a bias voltage used in any configuration. The initialization script initflam.pl sets the bias to 1.0 V, and then queries whether you wish to change the bias. *If MCE4 crashes and you have to run* initflam.pl*, don't forget to reset the bias for spectroscopy!*

The detailed procedures for aligning a long slit appear in the sections immediately following. Operation of the guider is included in these instructions; references to the relevant figures from the manual *FLAMINGOS at the KPNO 2.1-m: Telescope Console Control Panels and GUIs used for Guiding* (hereafter, *Guiding GUIs*) are included as an additional aid towards understanding the alignment procedure.

There are two types of slits which may be used for spectroscopy. There are a number of fixed long slits installed in the MOS wheel, in between the MOS mask locations, with widths of 2, 3, 6, 8, 12, and 20 pixels. Because of their proximity to the MOS masks, these must be used with the Decker wheel set to the slit position, and it is necessary to carefully set up the Decker wheel to ensure that the narrow aperture does not vignette the slit. There are also a number of custom slits which have been machined in MOS masks and can be used with the much wider MOS decker, which can greatly facilitate acquisition of the target.

Commonly used slits in MOS masks are:

UF 3pix	This is a single long slit 3 × 1680 pixels (1.81 × 1020 arcsec at 2.1-m)
NOAO 2 pix	The three NOAO slits are 2, 3, 4 pixels (1.21, 1.81, 2.42 arcsec) wide and
NOAO 3 pix	consist of two slits each 120 arcsec long centered 120 arcsec on either side
NOAO 4 pix	of a 20 arcsec square aperture which is used for acquisition

Unless the long slit length is required for science, the NOAO slit masks are more suitable for compact source spectroscopy because the acquisition aperture greatly simplifies centering the target on the slit.

6 These may change each time the instrument is mounted onto the telescope, but should be somewhat close to these values.

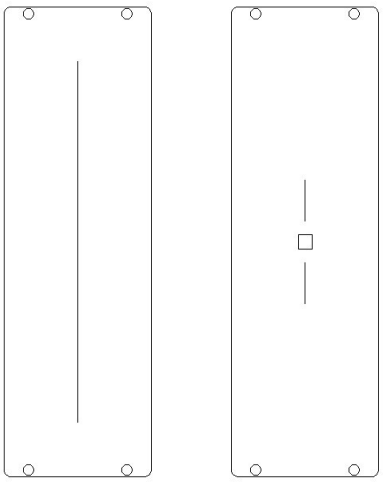


Figure 4: Schematic of the UF 3pix long slit (left) and NOAO slit (right). The acquisition box for the NOAO slit is 20 arcsec square at the 2.1-m. The two slits are each 120 arcsec long, centered 120 arcsec on either side of the center of the mask.

The general outline for spectral observations is:

1. Verify telescope pointing on a SAO or Fixed Bright star close to target position.
2. Acquire target close to the long slit center or alignment aperture in slit MOS plate.
3. Check focus.
4. Acquire a guide star and start guiding.
5. Insert appropriate decker baffle (long slit or MOS) and check its alignment.
6. Insert and align long slit or MOS plate slit.
7. Insert desired filter and grism.
8. Set bias to 0.75 V for spectroscopy.
9. Configure spectral dither pattern parameters.
10. Execute spectral dither pattern.
11. Take all of the required flats.
12. Repeat steps 1 – 13 with the long slit on a bright telluric standard star (G5-6 V) close by on the sky.[7]
13. You may want to also take a long slit spectrum of an A0 star at low airmass.
14. Take darks (10 - 20 each) at the exposure times used for sky wavelength calibrations. Darks are not needed for the science target and standard spectroscopy if the source is dithered on the slit or for dome flats taken using the "lamp on – lamp off" protocol. Be sure to use the spectroscopy bias of 0.75 V. These may be done in the afternoon.

7 If you intend to use the 3-pixel MOSplate long slit, you can leave the decker positioned at the MOS baffle.

The following commands are used for long slit and MOS plate spectroscopy:

On the Flamingos command line:

config.exposure.pl	Set up the filename and exposure time.
config.filter.grism.decker.wheels.pl	Set up and move Filter or Decker wheels.
config.rel.mv.filter.grism.decker.wheels.pl	Execute *relative* motion of Filter, Grism, or Decker wheel
config.rel.mv.mos.wheel.pl	Insert long slit or MOS plate slit.
config.mos.dither.kp2m.pl	Set up the spectroscopy ABBA parameters.
dither.mos.nonudge.kp2m.pl	Take spectroscopic data in the ABBA pattern.
guide.define.abba.manual.beams.kp2m.pl	Set lock positions for the A and B beams.
guide.define.slit.center.manual.kp2m.pl	Set lock position 1.
guide.mos.offset.kp2m.pl	Make guided relative telescope offsets.
set.bias.pl	Change bias for imaging or spectroscopy.
tweak.decker.pl <delta_angle>	Adjust the Decker wheel position by angular increment.
tweak.mos.pl <delta_angle>	Adjust the MOS wheel position by angular increment.

At the iraf cl prompt:

imexam	Measure slit profiles and stellar centers (keys: a, r, j, k, x, g, i).

B. Preliminary Setup

Our experience with FLAMINGOS leads us to note that the efficiency of setting up on targets for spectroscopy can be significantly improved by carrying out some preliminary work during the afternoon or at the beginning of a spectroscopic run. Unlike an optical spectrograph, FLAMINGOS has no facility for viewing the field on the slit, and target acquisition must be carried out by imaging through the slit onto the science array. Fortunately, the motions of the Decker and MOS wheels appears to be quite reproducible, and the relative motion scripts incorporate backlash removal, so it is possible to measure the location of the slit apertures on the array prior to observing and move the target to the appropriate detector coordinates, and then move the slit into the beam with confidence that it will be close enough to be centered up. This strategy greatly reduces the number of time-consuming wheel motions.

- During the afternoon, after the masks are loaded, the support astronomer should check the orientation of the masks with respect to the columns of the array by taking images in the Ks filter and tweak the zero point of the MOS wheel motion using the ufmotor commands until the masks are precisely aligned with the columns of the array. The mask stepper motor positions are sufficiently accurate so that alignment of one mask should result in the other masks being aligned to within 3 – 4 pixels over their length.

- Once this is done, the support astronomer or the observer should cycle through the masks and measure the [x,y] position on the array of the center of the alignment hole and/or the center of the long slit and note these positions. This will save a lot of time during the night.

- If doing spectroscopy with one of the long slits in the MOS wheel (not one of the masks), move the Decker wheel to the slit position and use the command tweak.decker.pl so that the image of the decker aperture is centered on the location of the slit which will be used for spectroscopy.

- If one is doing spectroscopy with one of the slit masks mounted in a MOS mask position, set the Decker wheel to the mos position. The 6 × 20 arcmin field is adequate for initial acquisition, and it is not necessary to move this wheel during the night.

C. Long Slit Alignment

1. *Verify telescope pointing*.
   - Acquisition can be done with the Decker wheel in mos, MOS wheel in imaging, Filter wheel in H, and Grism wheel in open1.
   - Take a quick image (2-5 seconds) of an SAO or Fixed Bright Star near the target field, and make certain the SAO star is well centered *at the position of the slit or acquisition aperture for the slit mask to be used*. If is not, center the star with relative.offset.kpno.pl, then take another image. Once it is well centered, Z the telescope *(cf. § III.B. Nightly Startup Tasks: Startup on the sky*).
2. *Acquire target field*.
3. *Adjust focus.*
   - The guide camera should be confocal with FLAMINGOS and should give a good starting focus.
   - Next, take a series of images with FLAMINGOS over a range that covers best focus, offsetting the telescope between each image; use relative.offset.kpno.pl and dither back and forth by 10 – 20 arcseconds. Run fwscan on the stack of images to determine which focus setting was best (*cf. § III.B. Nightly Startup Tasks: Startup on the Sky*).
   - Alternatively, check the focus with imexam, key a or r and interactively focus the telescope.
   - Record the telescope secondary temperature, for reference.
4. *Acquire a guide star and begin guiding.*
   - In the Linux TV Guider GUI, Warp to Star.
   - In the Linux TV Guider GUI, use the Guide pull down menu, and select Guide On *(cf. Figures 6 & 8* in *Guiding GUI's)*
5. *Take another image, and measure the target centroid*. Use imexam, key a.
   - Move the telescope so that the target is centered at the (x,y) coordinates of the long slit center or the center of the acquisition box in the slit mask using guide.mos.offset.kp2m.pl.
   - To quickly estimate the distance to move, draw a large ruler in ds9, and then double click on it to get its pop-up GUI. Enter the (x,y) coordinates of the star, and the destination position along the slit. Then click on the Distance pulldown menu, and select Arcseconds. The (x,y) distances correspond directly to (East-West, North-South) motion.
6. *For long slit, Move Decker wheel to the* slit *aperture* using config.rel.mv.filter.grism.decker.wheels.pl. If using a MOS mask slit, move the Decker wheel to the mos aperture if it is not already there.
7. *Move MOS wheel to long slit or slit mask position*. Use config.rel.mv.mos.wheel.pl.
8. *Verify long slit is straight and still at the location measured earlier*.
   - Use imexam, as described in step 7, and measure across the slit with the j key at two different positions. If dx is > 1 pixel, you should straighten the slit using tweak.mos.wheel.pl.
9. *Take an image.* One should be able to see the target within the acquisition aperture if using a slit mask or within the slit if using a long slit
10. *Use* guide.mos.offset.kp2m.pl *to center the star in the slit or acquisition aperture*. Because one should be very close to the correct position, the motions should be small.
    - You may need to iterate this step, and peak up the flux from the object through the slit with additional guided offsets; changing the ds9 display parameters, using zmax and log scalings may help.
    - If using one of the NOAO slit masks, once the star is centered in the acquisition aperture, offset the telescope 120 arcsec to the north or south using guide.mos.offset.kp2m.pl to center the star in one of the slits. We recommend the lower (north) slit to avoid the noisy upper right detector quadrant.

D. Taking Spectra Once the Slit is Aligned

There are two options for taking data once the target is aligned onto the slit. The first option is to manually perform the dither pattern, taking individual images after each guided offset. We sometimes do this for long slit data of calibration stars, if we want to walk the star along the slit in a pattern other than an ABBA pattern. Alternatively, one may use the standard ABBA dither script.

Walking up the slit:

- Move the star up the slit in steps of 10" for a total of 5-7 positions. The MOS mask slits are 120" long, so one can easily stay within the slit.
- Use singleimage.pl to take an image at every location.
- Use guide.mos.offset.kpno.pl to move the star up and down the slit (while continuing to guide).

Setup to execute a dithered ABBA script:

1. *Set up lock position definition for the current guide position.* This requires you run a script on *flamingos1a* which prompt you through a sequence of steps with the Linux Guider GUI on *teal*.
   - *Login to flamingos1a from teal*. Open a terminal, and use ssh to login as 2mguest (*cf. § II−Starting FLAMINGOS).* Keep this window open when finished with these steps.
   - *Define the current lock position.* Type the following at the 2mguest prompt:

     ```
     2mguest@flmn-2m-1a{1} guide.define.slit.center.manual.kp2m.pl
     ```

     You should see the following output (some extraneous debugging info is excluded):

     ```
     This script will walk you through the guider gui on Teal, in order to define guide lock postion 1 at the current guiding position.

     The MOS plate alignment stars should be well placed in their boxes, and the MOS objects in the center of their slits.

     You should be guiding.

     Are you ready? (y/n)
     ```

     When ready, type "y", and follow the instructions for interacting with the Linux TV Guider GUI. Here are the instructions it will give:

     ```
     On the guider gui on Teal:
     select 'Locks --> Clear lock positions'
     Done?(y/n)y

     On the guider gui on Teal:
     select 'Locks --> Define lock position 1'
     Done?(y/n)y

     May not need this step:
     On the guider gui on Teal:
     select 'Locks --> Goto lock position 1'
     Done?(y/n)y

     On the guider gui on Teal:
     select 'Markers --> Add marker at current box center'
     Done?(y/n)y
     ```

     This script next needs to query the guider for the current lock position. This is necessary if we ever decide that nudging the MOS observation is possible on repeats of the MOS ABBA pattern.

     ```
     Are you ready? (y/n) y
     ```

Answer "y" to this last query; it will then print some numbers and other information to the screen. It will conclude with:

The MOS dither script requires the slit center have zero offsets.

Clear the present offsets (i.e. set to zero)? (y/n) y

Answer "y" to this query. It will set the offsets (see *cyan's* telescope status screen) to zero, but it will not move the telescope. The following output will be printed, and the script will be finished.

EXECUTING CLEAR OFFSET COMMAND:
/usr/local/uf2001May17/sbin/tcs2m "tele offset = zero"

2. *Configure the spectral dither sequence* using config.mos.dither.kp2m.pl.

   - Set M_RPTPAT to the number of times to repeat the pattern.
   - Set M_THROW, the distance in arcseconds between the A & B beams (which are symmetrically offset about the telescope zero point−the final step of the previous script). *This parameter must be correctly set before moving onto the next step in this sequence.*

3. *Set up lock positions for the dither beams (A & B), ending in beam A*. Type the following at the 2mguest prompt:

   2mguest@flmn-2m-1a{2} guide.define.abba.manual.beam.kp2m.pl

   You should see the following output (some extraneous debugging info is excluded):

   Before you start:
   1) Make sure the MOS alignment stars are centered on their boxes.
   2) The present position is defined as lock position 1.
   3) The telescope has been guiding.
   4) The telescope has zero offsets.

   This script will define lock positions 2 & 3 as beams A & B,and place markers at each location.

   Order of action:
   1) Offer to clear the offsets, in case they're not already zeroed.
   2) Turn off guiding.
   3a) Offset telescope to beam B.
   3b) Move guide and AOI boxes guide star in to beam B.
   3c) Define position as pos3, and place marker.
   4a) Offset telescope to beam A.
   4b) Move guide and AOI boxes guide star in to beam A.
   4c) Define position as pos3, and place marker.
   5) Turn on guiding.

   PA of slit on sky = 0.00

   Telescope offsets in arcsec

   Beam dra ddec
   A 0.00 4.00
   B 0.00 -4.00

```
Are you ready? (y/n)
```

This script will prompt you through the above 5 steps. Do them *quickly*, as guiding will be off during them, and it needs to be restarted as soon as the last beam is defined. Answering "y" will generate the following output:

```
<><><><><><><><><><><><><><><><><><><><><><><><>
Step 1) Clear offsets.
If the telescope offsets are not zero, then they need to be zeroed.
Clear the offsets? (y/n)y

EXECUTING CLEAR OFFSET COMMAND:
/usr/local/uf2001May17/sbin/tcs2m "tele offset = zero"

Step 2: Guiding off.
Executing /home/raines/gdrrpc/gdrrpc guide off

Step 3a) Offset telescope to beam B.
EXECUTING OFFSET COMMAND:
/usr/local/uf2001May17/sbin/tcs2m "tele offset = 0.00, -4.00"

Step 3b) Manually move guide and AOI boxes to guide star.
      On teal (the telescope control computer) run the 2m guider GUI.
      While the gui has mouse focus, hold the shift while pressing the
      arrow keys to move the guide boxes to your desired guide star.
Is it in location? (y/n) y
```

Quickly move the mouse cursor to hover over the Linux TV Guider GUI. Then use the up and down arrow keys to move the guide box (the script says to hold the shift key, too, but this is no longer necessary) until is is centered over the guide star. You should only need to move the up and down arrow keys. This defines beam B, and lock position 2. Type "y" immediately after getting the box aligned, in order to move onto beam A.

It will query the guider about the current position, and print some info to the screen. The next important bit defines the final beam, A:

```
Step 4a) Offset telescope to beam A.
EXECUTING OFFSET COMMAND:
/usr/local/uf2001May17/sbin/tcs2m "tele offset = 0.00, 4.00"

Step 4b) Manually move guide and AOI boxes to the _SAME_ guide star.
      On teal (the telescope control computer) run the 2m guider GUI.
      While the gui has mouse focus, hold the shift while pressing the
      arrow keys to move the guide boxes to your desired guide star.
Is it in location? (y/n) y
```

Quickly move the mouse cursor to hover over the Linux TV Guider GUI. Then use the up and down arrow keys to move the guide box (the script says to hold the shift key, too, but this is no longer necessary) until is is centered over the guide star. You should only need to move the up and down arrow keys. This defines beam A, and lock position 1. Type "y" immediately after getting the box aligned. As in the other beam, it will query the guider about the current position, and print some info to the screen. The final important step resumes guiding, now in beam A if you answer "y":

```
Step 5) Start guiding in beam A?(y/n) y
```

It should print out some statements such as

```
Moving guide box to lock position 2.
Executing /home/raines/gdrrpc/gdrrpc guide pos2
gdrrpc reply =
Executing /home/raines/gdrrpc/gdrrpc guide on
```

At this point three guide lock positions have been defined, and the telescope is locked and guiding in beam A, which is 4" away (*South*, I think) from the initial alignment position for the long slit.

4. *Insert filter and grism combination* with config.rel.mv.filter.grism.decker.wheels.pl [Move Wheels].
5. *Verify bias* is set to 0.75 V for spectroscopy when prompted after moving the Grism wheel.
6. *Configure filename and exposure time with* config.exposure.pl
7. *Start spectral dither sequence*, dither.mos.nonudge.kp2m.pl. Repeat as necessary.
8. *Take one or more sets of dome flats at end of dither sequence* (*cf. §. V. E. Taking Spectra with FLAMINGOS: Taking Flats and Wavelength Calibrations)*.
9. *Take a long slit spectrum of a telluric absorption star at a similar airmass to that at the middle of the dither sequence.* Use a bright star with spectral type G5-6 V.
10. *Some observers also take a long slit spectrum of an A0 V star.*

E. Taking Flats & Wavelength Calibrations

There are two types of calibrations required for long slit and MOS spectra: wavelength calibration and flat fields. Because the 2.1-m guider is removed to install FLAMINGOS, there is no built-in set of arc lamps or quartz lamps for these calibrations. Since there are no arc lamps, wavelength calibration must be done using the OH sky lines present in the target spectra. These lines are generally not saturated even for integration times as long as 600 seconds.

Flatfields must be obtained using the imaging flatfield lamps and a blank section of dome (not necessarily the white spot). *These data should be taken contemporaneously with your target:* there may be flexure between the slit and the detector which is dependent on telescope hour angle (HA) and zenith distance (ZD). Additionally, if one tries to take them at a later time, it may not be possible to precisely insert the slit and grism in exactly the same way as they were when set up on the target. More than one flat field data set may be required if the observation spans a large enough range of hour angles ($\geqslant$ 1 hour, possibly).

We recommend the following:

- If the target is a bright standard star, then the observation time probably is short and a single set of calibrations, *taken after the target*, should suffice.

- If the target is faint, and the time on source is long, take more than one set of flats at several different hour angles that lie within the same range of hour angles as covered by the science target, but *take them all after finishing the target observations*. For example, if the science target is taken over the hour angle range from -2:30 to +1:00, take a set of flats at the final hour angle, then move the telescope back to an hour angle similar to the initial hour angle to take another set of flats (the telescope does not need to be tracking). Or, if you only have time for one set of flats, consider moving the telescope to the midpoint of the track in hour angle.

The following procedure is used for taking flats after taking science target spectra. The alignment of the slit, filter and grism should not have been changed from that used for the science target. This procedure can easily take 15 or more minutes, as the dome has to be properly positioned.

1. *Carry out the following steps at the telescope:*
   - Stop guiding (*cf.* Figure 8 of *Guider GUI's*).
   - Turn down the guide camera gain (*cf.* Figure 3, *ibid*).
   - Turn on the dome flatfield lamps *(cf*. Figure 11, *ibid*). The low lamps at full power (84 V) should give ~2400 ADU in JH-band with the JH grism in 30 s; if this sort of illumination level is not achievable in a reasonably short integration time (< 60 s), or if you want more signal, then you will need to use the high lamps, but probably at a low voltage (24 V is the minimum).
   - Turn dome tracking Off in the *XTCS* GUI (*cf.* Figure 9, *ibid*).
   - Enable the MAIN button on PANEL B, to take the telescope out of AUTO (*cf.* Figure 9, *ibid*).
   - Use the hand paddle (*cf.* Figure 10, *ibid*) to rotate the dome until a relatively blank section of silvery dome is completely in front of the telescope.

     If the target is too close to zenith, it will not be possible to use the side of the dome. Instead, record the hour angle and declination of the telescope, then send the telescope to zenith and close the mirror covers. Then close the dome and reopen the mirror covers and, finally, send the telescope back to the recorded hour angle and declination. Set the dome so that the telescope is looking at the closed slit.
2. *Set filename and exposure time.* Use config.exposure.pl.
   - Integration times of 30 s should give ~2400 ADU for JH- and HK-band spectroscopy.
   - Take a test exposure (singleimage.pl). The counts should be < 25,000 ADU for wavelengths < 2.4 μm.
   - With 30 second integration times, it is possible to do 8 reads, if you can accept the little bit of extra overhead.
3. *Take at least 5 flats with the lamps on.* Use more.single.images.pl 5.
4. *Turn down the flatfield lamps to lower voltage, or turn them off.*
   - Flats at two different illumination levels are differenced to remove the dark current.
5. *Take at least 5 flats with the lamps at the lower voltage.* Use more.single.images.pl 5.

VI.Shutting Down at the End of the Night

At the end of a long and (we hope!) productive night of observing, there are a few things that need to be done. In order, they are:

1. *Move the wheels to their default positions*. Using the scripts config.rel.mv.mos.wheel.pl [Move MOS Wheel] and config.rel.mv.filter.grism.decker.wheels.pl [Move Wheels] send the MOS wheel to imaging, the Decker wheel to imaging, the Filter wheel to J, and the Grism wheel to true_dark.

2. *Take any necessary dark frames.* Now that the grism is in the true_dark position, you will be able to take dark frames. We recommend 10-20 darks per exposure time. Use the set.exposuretime.pl, set.filename.pl, and the more.singleimages.pl scripts or a cshell script to complete this task.

3. *Fill the MOS Dewar.* Use the same procedure as at the beginning of the night.

4. *Replace the MOS window cover.*

5. *Begin writing the transferred data to DVD or USB drive (if not taking more darks).*

VII.At the End of Your Run

Make certain that you have transferred all of your data to *second-1 or second-2*, and written it to DVD, USB drive, your laptop or home institution. Although data from all Kitt Peak telescopes are archived, we still suggest that you make all necessary copies of your data, or back it up on a laptop, *before you leave the mountain.*

Also, please delete your data from *flamingos1a* as you leave.

Finally, please do not close any of the FLAMINGOS windows. Leave them open for the next observer, or for the Kitt Peak Instrument crew, as they will need them open in order to properly shut down FLAMINGOS if they are doing an instrument change after your run.

We hope you have many clear, sleepless nights, and acquire all the data you desired.

VIII. Troubleshooting

1) Problem: The image looks funny. You can see all 32 amplifiers, and the signal level is ~58,000 ADU; the preceding or following image(s) has 0 counts.

Solution: This is a hardware problem related to electrical noise causing an early readout of the detector. In imaging mode, MCE4 reads the array once, and then lets it integrate before reading it again *(cf. Appendix 2: Readout Schematic)*. The final image written to disk is the difference of these two images. This problem occurs when MCE4 spits out the image before making the second read and difference. There is nothing you can do to resolve the problem.

Typically, we get bad reads for about 2-5% of the images taken for exposure times ≤ 60 seconds. If you are getting a much higher failure rate you should call for help. You should be cautious with the image immediately following a bad read frame, because the ADU level in the image is frequently lower than it should be.

We have found that if you get more than two zero frames in a row, then the MCE4 array controller needs to be rebooted and reinitialized. See the solution to item 4a of the Troubleshooting Guide for how to do this. **NOTE:** the first image taken immediately after rebooting MCE4 also looks like a bad read.

Important Note: If the detector is saturated due to excess radiation, one will get an image which looks very much like a bad read. If rebooting the MCE4 does not solve the problem, move the grism to the true_dark position and take another image. If the problem persists, call for help. A saturated image will have a level ~ 49000 ADU, and the dead pixels in the lower left will be evident; a bad read has a level ~ 58000 ADU and the dead pixels are not seen (Fig. 5).

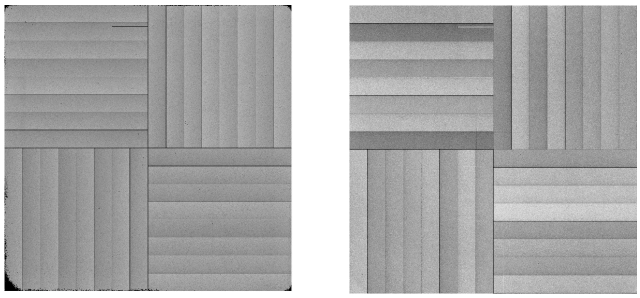


Figure 5: Images resulting from flux saturation (left) and a bad read (right).

2) Problem: The image looks funny. Various bits of it are scrambled or not in the correct position, or some bits of it are completely black (0 ADU).

Solution: See if the next image looks normal, if it does keep taking data. If the next image is similarly messed up, then the MCE4 array controller needs to be rebooted. See the solution to item 4a.

3) Problem: Excess Background

Possible solutions:

a) Image a very bright star (V ~ 2) in the Ks band, with the telescope way out of focus, say 2000 units lower. You should see a donut with a central obscuration and spider vanes. If it's not circular, then there could be something obscuring the beam such as the dome, the mirror covers, or a mispositioned filter, lyot stop, or Grism wheel.

b) Check that the ion gauge on the Granville-Phillips pressure monitor is off. When left on, the filament

casts a large amount of thermal radiation on the lower right hand corner of the array.

c) Check that the MOS dewar temperature is lower than 200 K. If the temperature is not between 80 – 95 K, and is rising monotonically with time, the MOS dewar may have run out of LN_2. Verify that the camera dewar is cold by checking the detector temperature, which should be near 77 K.

4) Various Problems related to image readout, wheel motion and Perle communication.

The three daemons started by initflam.pl (temperature, motor, and MCE4) work by issuing commands to particular hardware addresses on a networked device called the *perle* (previously the *iocomm*). This device is like a multiplexer. We have three devices (the temperature monitor, the motor controller, and the MCE4 array controller) which accept commands via serial ports. The *perle* has one serial port connection for each device. Commands from the software daemons running on *flamingos1a* are received by the *perle* via an ethernet connection, and then passed to the correct device.

Troubleshooting several types of problems involves deciding if the problem is intrinsic to the device, or to the communication via the *perle* itself.

a) Problem: The image has not read out. The exposure time counter never appears.

Sometimes the array controller crashes before the image acquisition script issues the START command to MCE4. For example, a successfully started image acquisition should show:

```
/usr/local/uf/bin/ufdc -host flmn-2m-1a -port 52008 -acq "start -timeout 9 -cnt 1 -lut /usr/
local/flamingos/flamingos.headers.lut/Flamingos.lut -fits /usr/local/flamingos/flamingos.hea
ders.lut/Flamingos.fitsheader -file /data0/2mguest/Test/test -index 2"

If it hangs here for more than ~6 seconds, type ufdc -q status in another flmn-2m-1a window

ufdc> greeting: UFGemMCE4Agent -- accepted client: ufdc@flmn-2m-1b@2002:350:03:40:49.170980
2002:350:03:40:49.170980
2002:350:03:40:50.440745ufdc@flmn-2m-1b
START

GATIR *Flamingos Beta* 2.00_f.07 >>

>>>>>.....TAKING AN IMAGE OR APPLYING LUT.....
(Exposure time + number of reads = 3 + 1)
Have slept 3 seconds out of an exposure time of 4 seconds
```

If you do not see the START command and the exposure time counter above, then MCE4 has crashed. The statement in the output above that saying to type ufdc -q status is a red herring, doing so will not change anything.

Solution: Reboot MCE4 and reinitialize it with initflam.pl. To reboot MCE4 telnet to *baytech* from *flamingos1a* with userid *mce4pow* and password _____[regular flamingos1a password]. Type reboot 1, and wait for the prompt to return. Then type logout. Example output from this procedure follows:

```
4mguest@flmn-4m-1b{2001}telnet baytech
Trying 140.252.53.86...
Connected to baytech.
Escape character is '^]'.
```

```
  RPC-3 Telnet Host
  Revision F 4.20a, (C) 1999
  Bay Technical Associates
  Unit ID: flmn-4m-1b

  Enter username>mce4pow
  Enter password>_____[regular flamingos1a password]
Option(s) installed:
True RMS Current
Internal Temperature

True RMS current:  1.6 Amps
Maximum Detected:  1.7 Amps

Internal Temperature: 18.5 C

Circuit Breaker: On


Selection    Outlet    Outlet    Power
 Number      Name      Number    Status
    1         mce4       4        On

Type "Help" for a list of commands

RPC-3>reboot 1
(Now it counts down for 10 seconds before applying the power).
RPC-3>logout
```

Now run initflam.pl at the *flamingos1a* prompt. You do not need to close any of the daemons to rerun initflam.pl for this problem. At the start, initflam.pl will complain that the motor and mce4 daemons are not up and listening, and ask if you want to continue. You do want to continue, as the daemons were working properly before the crash of MCE4. MCE4 must be reinitialized, in order to set the proper clocking of the array. If you were taking a spectrum, you need to reset the bias to 0.75 V. After it has successfully initialized the EDT frame grabber (where it says "do you see 10 lines of text between a line saying opening pdv unit 0 and a line saying done"), it will ask if you want to continue. You can type "y" at this point.

Next, you need to take two junk frames with short exposure time (*e.g.,* 3 seconds). The first frame after repowering and initializing MCE4 will look like a bad read; however, the second frame should look normal.

b) Problem: The image will not read out. A communication error message appears.

The following error message appears during the integration:

```
UFClientSocket::connect> unable to connect to flmn-4m-1a, port #
52008Connection refused
ufdc> unable to connect to MCE4 command server agent...
```

Solution: The fiber optic serial communications between the *perle* and the MCE4 controller may have been switched off inadvertently. There are two fiber converter units, one below the MCE4 controller on the left-hand rack, the other below the *perle* on the right-hand rack (Figure 6, below). Each has two small toggle switches, which must be set so that the red and green LEDs are OFF. The LEDs are used only for

testing that the fiber is working.

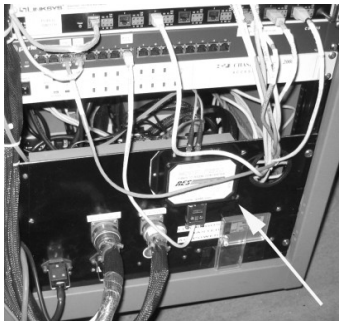


Figure 6: Fiber optic converter boxes below MCE4 (left panel) and below *perle* (right panel)

c) Problem: The image acquisition counts past the exposure time without reading out an image.

Solution: This problem rarely happens anymore. With the previous slower version of *flamingos1a*, it would sometimes take an extra 5 to 10 seconds to finish reordering the pixels; i.e., applying the look up table, or LUT, before writing the image to disk. In the MCE4 daemon window you should see string of dots being printed out during the apply lut phase:

```
UFEdtDMA::applyLut> . . . . . .
```

You should watch for several seconds to see if this line is present, and that it is printing additional dots. When it finishes, it should also print something similar to:

```
UFEdtDMA::takeAndStore> close mmap file:  /data/2mguest/Test/test.0002.fits
UFEdtDMA::> completed: 1 -- /data0/2mguest/Test/test.0002.fits
ufgtake> acquired frames: 1
UFEdtDMA::takeAndStore> close mmap file:  /data/2mguest/Test/test.0002.fits
UFEdtDMA::> completed: 1 -- /data0/2mguest/Test/test.0002.fits
ufgtake> acquired frames: 1
```

If this never appears, try typing ufstop.pl -stop -clean at a *flamingos1a* prompt. Then try taking another image; if that fails see if ping perle returns with the message that the *perle* is alive. If the *perle* is alive, try rebooting MCE4 and reinitializing. If that completely fails, call for help.

d) Problem: A large number of error messages are printed out either when trying to move a wheel (e.g., with* config.rel.mv.filter.grism.decker.wheels.pl [Move Wheels]*), or during the first part of an image acquisition, where it sends commands to MCE4.

Solution: It's possible that the *perle* (formerly *iocomm*) has crashed, or is very confused. Try ping perle from *flamingos1a*; if there is no response, it needs rebooting. Even if there is a response, it may be advisable to reboot it. To do this telnet baytech, userid *perlepow*, password _____[regular flamingos1a password]. At the prompt type reboot 1, and then type logout when the prompt returns (e.g., see the example output in *3a*, above). Now you must close all three daemons (Temperature, Motor, and MCE4) and the record_temperatures window and run initflam.pl.

***5) Problems when running* engineering.configure.filter.grism.decker.wheels.pl [Initialize Wheels], config.rel.mv.filter.grism.decker.wheels.pl [Move Wheels] *or* config.rel.mv.mos.wheel.pl [Move MOS**

Wheel]. ***The script ends by saying that the time for the wheel's motion to complete has expired.***

The Initialize Wheels button will execute the script engineering.config.filter.grism.decker.wheels.pl, which will rotate the wheels until the home position switch is activated, tell the controller to zero the position, and then move to the commanded position. We refer to this as a *home-type* of *limit*, or *limit switch* operation. The Move Wheels and Move MOS Wheel commands operate in a relative mode, and it will move the relative number of steps from one position to another, with a small overshoot and reversal to correct for backlash. We usually recommend the Initialize Wheels button for the first motion of those wheels, then use the Move Wheels button because the motions are shorter. Since the MOS wheel does not have an operating limit switch, the relative motion command must be used for all motions.

There are two modes of failure for each wheel.

(1) The limit switch fails to engage. If the wheel operates with a limit-switch home type, then the wheel can spin endlessly, and the perl script will just give up after some time limit. If you can stop the wheel and determine the location of the mechanism, it is possible to recover from such a failure and then use the config.rel.mv.filter.grism.decker.wheels.pl [Move Wheels] command for relative motion..

(2) The wheel binds, and a grinding noise is audible if you stand next to the dewar. If this happens there usually is no quick recovery after you have stopped the motor.

Solutions:

a) First, you must stop the wheel that is either spinning endlessly, or is jammed.

1. Type **CTRL-Z**, type jobs, kill -9 %<jobnumber> if the perl script has not yet finished and you already know that there is a problem.
2. Type ufmotor -host flmn-2m-1a -port 52004
   a) At the motor prompt, type <motor_name>@, where <motor_name> is one of letters *a, b*, *c*, *d*, or *e*, where motor *a = decker*, *b = mos*, *c = filter*, *d = lyot*, and *e = grism*. This should do a *soft-stop* of the motor.
   b) Type exit to quit ufmotor.
3. Type turn.off.motor.hold.current.pl

If this does not stop the motion of the wheel (e.g., you can hear it spinning or grinding), the last recourse is to turn off the motor controller itself. ***Note: any wheels that use near-home type and are not at home will be lost when the motor controller is powered up again. You should call for assistance if this happens.*** To cycle the power on the controller, telnet baytech as motorpow, password _____[regular flamingos1a password], and then reboot 1, and logout to exit.

b) If the failure was of the limit switch, you need to recenter the mechanism in question, and redetermine the home point. The best way to do this is to image a very bright star with the telescope out of focus by about 3000 units. The wheel probably is not well centered, so use one of the tweak scripts to adjust it (there are special engineering tweak scripts, in addition to the ones for the decker and MOS wheels). Then step the wheel by discrete positions, and measure the background. With some help you should be able to determine where you are, and use the ufmotor command <motor_name>o to rezero the wheel (yes, that is lower-case "o").

c) Because the MOS wheel is operating in relative motion mode (see above), vignetting problems or rebooting the motor controller with the MOS wheel not at home (imaging position) will require adjustment with the engineering.tweak.mos.wheel.pl script, NOT by attempting to home the wheel. Once it is at the imaging position, set the counter to zero with the ufmotor command bo.

IX. Contacts & Further Information

1. Dick Joyce, Ron Probst, and/or Nick Raines will help new observers during their first night of observing with FLAMINGOS at the 2.1-m. If simple questions arise during the run, please address them first to Dick or Ron, and then to Nick. Their contact information is listed below.

   Nick Raines, University of Florida, FLAMINGOS support scientist
   office 352-392-2052, ext. 244
   home: 352-870-0004
   raines@astro.ufl.edu

   Dick Joyce, NOAO Friend of FLAMINGOS
   office: 520-318-8323
   home: 533 (from mountain)
   rjoyce@noao.edu

   Ron Probst, NOAO Friend of FLAMINGOS
   office: 520-318-8268
   home: 521 (from mountain)
   rprobst@noao.edu

2. Updates to this manual and other manuals, and more information, may be found on the web:

   - Kitt Peak/NOAO web site — www.kpno.noao.edu/manuals/flmn
   - University of Florida — www.flamingos.astro.ufl.edu/index.html
     www.flamingos.astro.ufl.edu/Manuals/
   - Nick Raines' web page — www.astro.ufl.edu/~raines
   - Richard Elston's web page — www.astro.ufl.edu/~elston/flamingos/home_frame_set.html

3. In the event of a power outage for which the mountain does not switch to generator, please contact the mountain staff about properly shutting down the FLAMINGOS computer *flamingos1a.* There is a shutdown manual available off of the Manuals web page, but the procedure requires someone with root access (*e.g.,* the mountain staff, or anyone on the list above).

X. Acknowledgements & Other Bits

This version of the manual is substantially more complete than previous versions. Information has been incorporated from previous versions written by Katherine Wu, and Richard Elston and Elizabeth Lada. Helpful suggestions, comments and questions came from: Joanna Levine, Michael Ledlow, Jay Elias, Ron Probst, Dick Joyce, Mark Dickinson, Peter Eisenhardt, Dan Stern, and many FLAMINGOS observers.

Written in StarOffice 6.0, a nice program, but with a buggy Postscript driver. Finally revised in OpenOffice 3.0, which has a built-in PDF exporter.

Appendix 1: FLAMINGOS Command Listing and Partial Description of Function

A. Basic Instrument Configuration Commands

config.exposure.pl	Set object, filebase, data directory, exposure time.
config.filter.grism.decker.wheels.pl	Set up and move Filter and Decker wheels.
config.rel.mv.filter.grism.decker.wheels.pl	Execute *relative* motion of Filter, Grism, or Decker wheel
config.rel.mv.mos.wheel.pl	Move the MOS wheel in relative motion mode.
initflam.pl	Initialize FLAMINGOS. Start daemons and MCE4 array controller.
set.bias.pl	Imaging use bias = 1.0 V; Spectroscopy use bias = 0.75 V.
set.exposuretime.pl	Exposure time is in integer seconds; 2 seconds is the shortest.
set.filename.pl	Set image rootname and directory.

B. Basic Imaging Configuration and Acquisition Commands

config.dither.kpno.pl	Select dither pattern and number of repeats.
dither.source.kpno.pl	At present, only dithers on source in a square grid.
fast.singleimage.pl	Take a 1500 ms exposure time image.
more.singleimages.pl #	Takes # of images with parameters set by config.exposure.pl.
singleimage.pl	Take an image with present integration parameters.
config.dither.strip.kpno.pl	Set up a running strip of square dithered images.
dither.strip.clear.kpno.pl	Take a running strip of square dithered images.

C. Basic Spectroscopy (MOS and Long Slit) Configuration and Acquisition Commands

config.mos.dither.kp2m.pl	Setup the spectroscopy ABBA parameters, including position angle.
dither.mos.nonudge.kp2m.pl	Take spectroscopy data in the ABBA pattern.
guided.mos.offset.kpno.pl	Execute a relative offset while guiding.
set.new.mos.plate.names.pl	Define names of new MOS plates so their names are in the header.

D. Advanced Imaging and Spectroscopy Commands

config.chippa.kp2m.pl	Set the chip PA on the sky.
config.slit.chip.pa.kp2m.pl	Set the PA of the slit wrt the chip.

E. Telescope Information and Motion Controller

clear.offsets.kpno.pl	Absorb offsets into the current position; zero coordinates.
offset.kpno.pl	Absolute offset wrt pointing center of telescope.
guided.mos.offset.kpno.pl	Execute a relative offset while guiding.
relative.offset.kpno.pl	Offset telescope wrt the present offsets.
wcsinfo.pl	Request the present TCS information.

F. Resetting the MCE4 Array Controller, the Motor Controller, and the Perle

From *flamingos1a*:

1. telnet baytech userid: mce4pow, motorpow, or perlepow
   password: _____[regular flamingos1a password]
   (For telnet from a Kitt Peak machine, the baytech's name is *flmn-2m-p*).
2. reboot 1
3. logout
4. If you rebooted the *perle* close all daemons (the TEMPS, MOTOR, and MCE4 xterm windows), otherwise leave them open.
5. initflam.pl

G. Data Transfer & DVD Burning

Data are written to disk on *flamingos1a* automatically. At the start of every night you should run the mirror script to move the data from *flamingos1a* to one of the MacMini computers, from which one can easily save the data to DVD, external USB hard drive, or transfer data to their home institution or laptop.

Don't even think about writing data to tape.

Instructions for moving data from flamingos1a to second-2:

- From *second-2* run ~/bin/mirror flamingos1a <dir>, where <dir> is the data directory in /data/2mguest on *flamingos1a*.
- One may plug an external USB hard drive into one of the USB ports on the *second-2* monitor. It will automount as /Volumes/TAG, where TAG is the ID of the disk. Then cd to the external disk, create a data directory, then cp the data from *second-2* to the disk.

Burning DVDs from second-2:

Insert a blank DVD into the *second-2* computer and it will bring up a dialog which asks if you want to burn data to the disk.

One may also ssh into second-2 from a laptop and scp or sftp the data directly to the laptop.

H. Instrument Engineering Commands

center.of.rotation.pl	Determine the center of rotation from 3 points.
config.location.pl	Copy the correct Flamingos FITS header for a telescope.
engineering.config.home.type.wheels.pl	Set Limit Switch or Near Home wheel motion.
engineering.config.rel.mv.filter.grism.decker.wheels.pl	Set up Filter, Grism, or Decker wheels using home switch
engineering.config.mst.pl	Set milliseconds *vs.* seconds timer usage.
engineering.config.output.pl	Various settings (unlock file, talk to TCS, png image, etc.).
engineering.ct10.singleimage.pl	Output the first read of a CDS read.
engineering.ct12.singleimage.pl	Output the first set in a multiple read.
engineering.ct17.pl	Don't ask.
engineering.ct40.takecnt.pl	Don't ask.
engineering.more.ct10.pl	Take multiple CT 10 frames.
engineering.more.ct17.pl	Take multiple CT 17 frames; may not work.
engineering.set.lyot.wheel.pl	Move Lyot wheel for each telescope.
engineering.soft.stop.mos.wheel.pl	Send an escape character to the MOS wheel controller.
engineering.tweak.filter.wheel.pl	Adjust the Filter wheel position.
engineering.tweak.grism.wheel.pl	Adjust the Grism wheel position.
engineering.tweak.lyot.wheel.pl	Adjust the Lyot wheel position.
readFITheader.pl -f /usr/local/flamingos.headers.lut/Flamingos.fitsheader	Print out the present FITS header template file for the next image.
turn.off.motor.hold.current.pl	Send command to Filter, Lyot and Grism wheel controllers.
tweak.decker.pl delta_angle	Adjust the Decker wheel position by angular increment.
tweak.mos.pl delta_angle	Adjust the MOS wheel position by angular increment.
ufidle.pl	Set MCE4 in continuous resetting mode on the array.
ufstop.pl -clean	Set various semaphores in /var/tmp/
ufstop.pl -stop	Stop the present integration.

Appendix 2: Readout Schematic

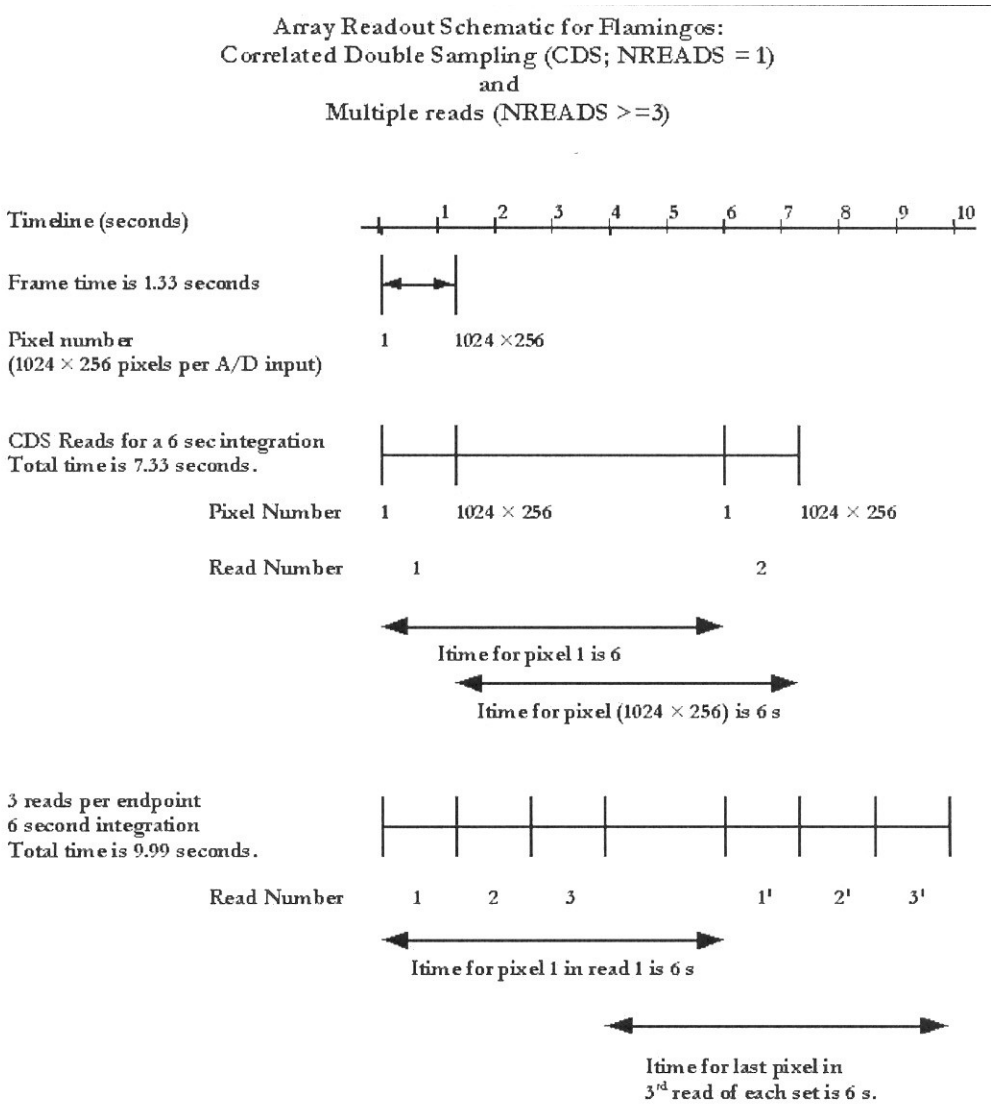


Figure 7: Array Readout Timing. All 4 quadrants of the array are readout simultaneously; within one quadrant all 8 amplifiers are readout, with pairs of amplifiers multiplexed down into one A/D input. Thus in a frame time of 1.33 seconds 1024 × 256 pixels are readout. The image delivered by MCE4 for a CDS frame is the difference image from two nondestructive reads of the array; the timing for a CDS frame with integration time of 6 seconds is shown. Note that the total time to take this frame is 6 + 1.33 seconds, but the net integration time for all pixels is 6 seconds. The case for 3 multiple reads is also shown. For a 6 second integration this takes ~10 seconds. MCE4 delivers the difference image of the sum of each set of 3 reads. Thus the final image with multiple reads is a *coadded* image; the pixel values will be 3 times larger than that obtained with a CDS read.

Appendix 3: XBOX Default Parameter List for Instrument at PA = 0 degrees

PACKAGE = ucsclris
TASK = xbox

image	=	target.0001	image
input	=	box1	input file (box locations)
(stars	=		) file of star centroids, using 'a' key in imexam
(nxbox	=	50	) nx of extraction box
(nybox	=	50	) ny of extraction box
(xsz	=	30.	) x box length (pixels @ .15mm/pix)
(ysz	=	30.	) y box height (pixels @ .15mm/pix)
(fwhm	=	4.	) star FWHM in x (pixels @ .21"/pix)
tel	=	2m	Telescope - 2m,4m,MMT or GemS
(rotdir	=	-1	) Enter rotator direction (1,-1)
rot_2m	=	0.	Enter 2m rotation offset
xrot_2m	=	1162.	Enter 2m center of rotation x
yrot_2m	=	-1868.	Enter 2m center of rotation y
invert2m	=	no	Enter if 2m field is flipped (yes/no)
rot_4m	=	-90.	Enter 4m rotation offset
xrot_4m	=	1162.	Enter 4m center of rotation x
yrot_4m	=	-1868.	Enter 4m center of rotation y
invert4m	=	yes	Enter if 4m field is flipped (yes/no)
MMT_rot	=	90.	Enter MMT rotation offset
MMT_xrot	=	1024.	Enter MMT center of rotation x
MMT_yrot	=	1000.	Enter MMT center of rotation y
MMT_inve	=	yes	Enter if MMT field is flipped (yes/no)
GemS_rot	=	0.	Enter Gemini South rotation offset
GemS_xro	=	1009.	Enter Gemini South center of rotation x
GemS_yro	=	989.	Enter Gemini South center of rotation y
GemS_inv	=	no	Enter if Gemini South field is flipped (yes/no)
(xoff	=	0.	) add'n. x shift to apply (pix)
(yoff	=	0.	) add'n. y shift to apply (pix)
(def_ref	=	0.2	) default error estimate
(def_err	=	0.2	) default error estimate
(niter	=	6	) number of iterations in fit
(box_siz	=	0.5	) box half-len (usually acceptable resid)
new_x_fw	=	4.	[Enter new x FWHM]
new_y_fw	=	4.	[Enter new y FWHM]
vmag	=	100.	[magnification factor]
wt	=	1.	[weight]
(coord	=	)	graphics cursor input
(mode	=	ql	)

Appendix 4: Additional Notes on MOS Plates

An example MOS plate for use at the 4-m is shown adjacent, in Figure 8, at approximately full size (~105 mm in length).

The sizes of the slits and alignment boxes are the same size in pixels for both telescopes.

The slitlets are 3 pixels (1.8" at the 2.1-m) wide, with a minimum length of approximately 30 to 40 pixels (18" to 24" at the 2.1-m).

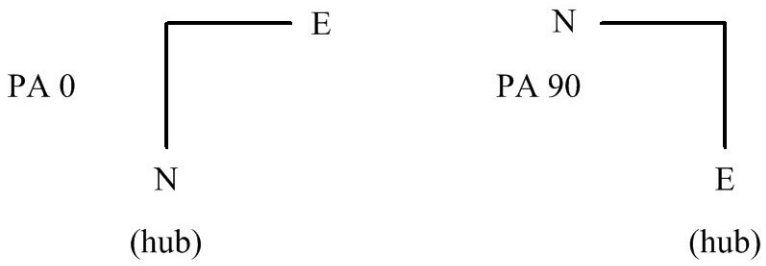
The alignment boxes are 25 to 30 pixels (15" to 18" at the 2.1-m) on a side.

The guide field is off-axis by approximately 160" *East* and 1500" *South*.

We usually try to find guide stars with K magnitudes in the range 11–13.

Note that the position angle always points toward the HUB of the MOS wheel and the masks are mounted into the wheel with the orientation in *sky parity* (E being ccw from N).

Figure 8: Example MOSplate.



The view of the MOS wheel, from the side that will be seen when loading is presented on the next page. Copy or download and print it (http://flamingos.astro.ufl.edu/Manuals/), and then annotate it as you load the plates.

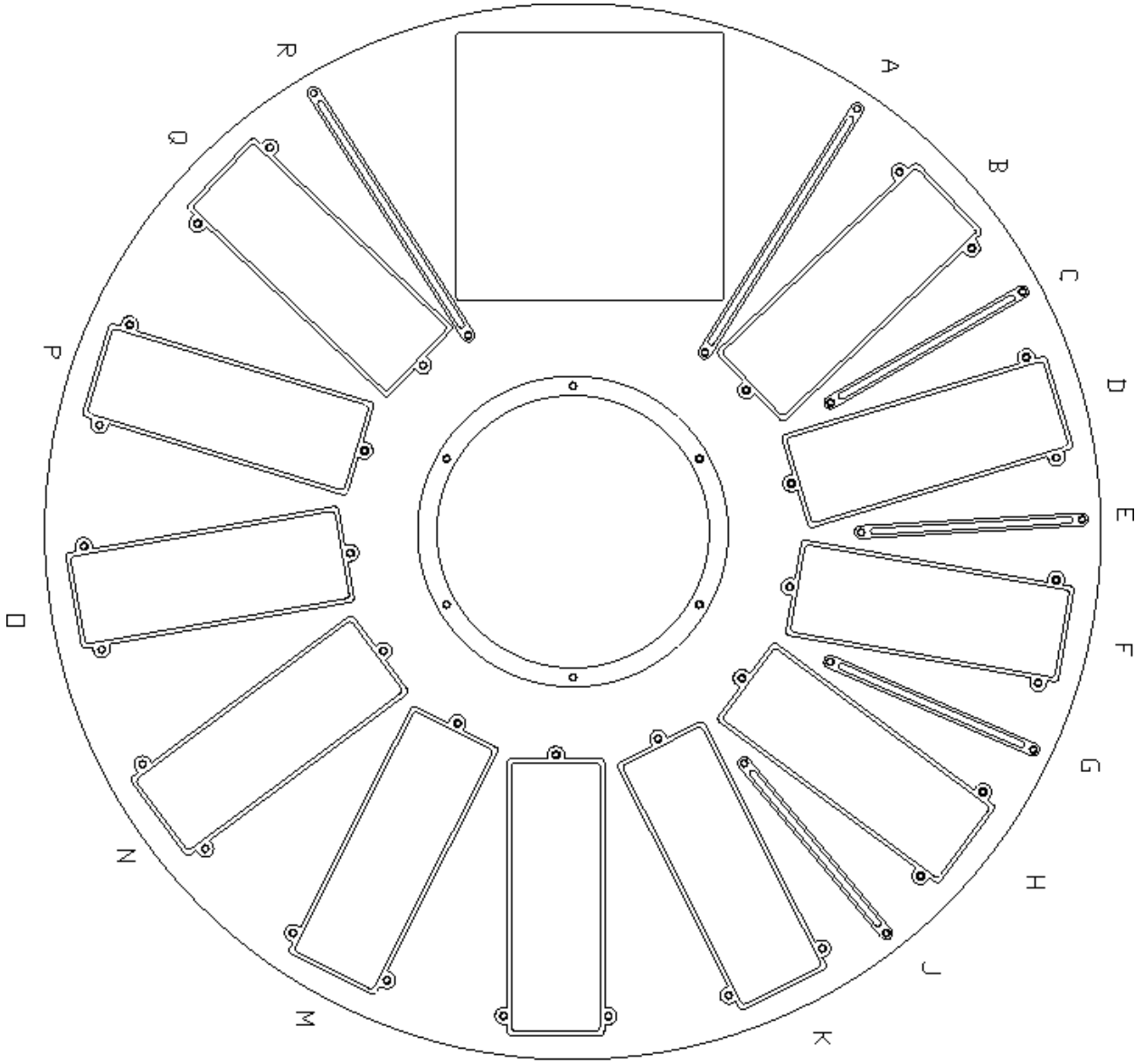
Critical annotation items include (see Figure 8):

- *Plate name or ID*
- *Rotator Position Angle for the proper plate orientation on the sky*
- *Slit Width, in pixels*
- *Compass, with sky parity showing the orientation of North and East*

After the wheel is back in the MOS dewar, and the dewar is on the pump, run the script set.new.mos.plate.names.pl, so that the correct plate name is recorded in the FITS header when the plate is selected.

Since multiobject spectroscopy is not currently supported at the 2.1-m, this information is relevant only to longslit masks mounted in MOS plate locations.

Appendix 4: Additional Notes on MOS Plates: ***A Figure of the MOS Wheel, Useful When Loading Plates***



MOS	*Position*	*PA*	*Name*	*MOS*	*Position*	*PA*	*Name*
B		_____	_____	*M*		_____	_____
D		_____	_____	*N*		_____	_____
F		_____	_____	*O*		_____	_____
H		_____	_____	*P*		_____	_____
K		_____	_____	*Q*		_____	_____
L		_____	_____				

Telescope: _____
Date Loaded: _____
Observing Program: _____